Ranking and Selection of Hazardous Air Pollutants For Listing Under Section 112(k) of the Clean Air Act Amendments of 1990

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Technical Support Document

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1. Introduction

EPA has published numerous guidelines for risk assessment that support the development of qualitative and quantitative estimates of risk to health. These guidelines are widely used and understood, and EPA considers them an appropriate basis for ranking and selecting hazardous air pollutants (HAPs) for the purposes of section 112(k) of the Clean Air Act (CAA) Amendments of 1990. This document describes EPA's use of risk assessment tools and information in selecting HAPs posing the greatest health risk in urban areas ("urban HAPs"), and a subset of urban HAPs that pose health risks as a result of emissions from area sources ("area source HAPs").

The essence of the Agency's model for risk assessment lies in a combination of two types of information. The first type of information concerns the nature of adverse effects caused by a substance (the "hazard identification"), and specific exposure levels at which the effects occur (the "dose-response assessment"). This information is based on human or animal studies of high quality, usually obtained from scientific journals. The second type of information concerns the amount, or dose, of the substance that receptors get from the environment. This "exposure assessment" is developed from actual measurements, mathematical models, or a combination of both. These two types of evidence--the dose that causes harm and the dose actually received--are combined in a "risk characterization" that describes the potential for real-world exposure to cause harm and the uncertainties surrounding this potential.

If it were possible to do so, the selection or urban and area source HAPs could reasonably be based on a quantitative national risk assessment for all HAPs in all urban areas. Such an assessment would include evidence of (1) doses of each HAP known to cause adverse effects (and the nature of those effects) and (2) estimated doses of each HAP that receptors in urban areas may actually receive from the environment. However, such a comprehensive risk assessment is not yet possible. The limitation is not that EPA does not know how to do a fully quantitative national risk assessment, but rather that we do not yet have some of the information needed to do it.

EPA's list of HAPs currently contains 188 substances and "categories" of substances. Many of these HAPs have not yet been subjected to toxicological testing, and existing test results for others have not yet been developed into dose-response assessments. Although 188 HAPs might seem to be a reasonably sized group to address, in fact it is much larger. Some HAP categories (*e.g.*, polycyclic organic matter, or POM) are broadly defined, containing thousands of individual chemical compounds with widely varying toxic potential. The scientific community is working hard to collect new toxicity data, and EPA and other regulatory agencies are working equally hard to develop these data into dose-response assessments. However, given realistic research and resource constraints, the sheer size of the HAP list precludes a complete understanding of HAP toxicity at this time.

To address exposure to HAPs, we would prefer to use measured personal exposures or ambient concentrations from monitoring stations. However, personal monitoring data are still rare, and EPA's ambient air monitoring activity focuses on criteria pollutants such as particulate matter and ozone. Some States and local governments fund and operate HAP monitoring stations, but these are based on the priorities of the funding agencies. For this reason, sampling strategies, lists of substances monitored, and analytical methods vary substantially from place to place. Many HAPs, and many locations, are not monitored at all. Consequently, ambient monitoring information provides important but limited evidence of exposure potential.

EPA's data for amounts of HAPs emitted from various sources is more complete than our ambient monitoring databases, but these emission data also have important limitations. EPA developed many of the national emissions estimates by applying an emission factor, or series of factors, to activity data thought to represent source categories nationally. Emission factors were developed from information from a small number of sources within a source category, or by professional judgment. Applying emission factors and activity estimates across all emission sources in a source category carries substantial uncertainties.

Furthermore, an emission rate does not equal an exposure. Before a receptor can be affected, the substances must be diluted and dispersed through the atmosphere, where some may be transformed to other substances or deposited before exposure occurs. To provide a more meaningful indicator of exposure, emission data can be input to a dispersion model capable of estimating ambient concentrations. Although our current national emissions inventory data do not include sufficient location data to support dispersion modeling, our inventory for 1996 (currently under state review) will support such modeling.

For these reasons, neither the dose-response nor the exposure database can currently support a direct, quantitative national risk assessment for HAPs in urban areas. Nevertheless, the Act requires EPA to select 30 or more HAPs posing the greatest threat to health and the environment in urban areas. Recognizing the above limitations, EPA is obligated to make decisions based on the best available information. EPA has based its proposal on the results of three separate hazard ranking analyses of information concerning HAPs in urban areas. These analyses were for the most part developed independently, although they are by necessity based on much of the same data. They were prepared by three different groups of scientists, although these groups communicated and exchanged ideas during their work. The three analyses arrived at conclusions that are in some ways similar, while varying significantly in others. EPA has endeavored to combine the results in a way that takes advantage of concordance among these groups and makes reasonable judgments in areas where opinions vary.

2. Methods

In 1997, EPA conducted an initial screening evaluation to develop a list of 40 candidate urban HAPs. The evaluation used three independent ranking analyses (a review of existing studies, an urban analysis conducted by the EPA Cumulative Exposure Project team, and calculation of risk-based ranking indices). Two of these analyses are summarized briefly in Sections 2.1 and 2.2 below, and presented fully as appendices to this document. The third analysis is described in detail in Section 2.3 below. Interested parties were invited to submit emission data to augment or replace information used to develop the list of candidate HAPs. EPA also subjected the screening evaluation methodology itself to peer-review by independent experts in air toxics and risk assessment. In early 1998, EPA held a full-day session of the peer-review panel to discuss the methodology and underlying data. The reviewers evaluated all facets of the methodology and its suitability for identifying HAPs for the urban HAPs list, the relative value of various data sources, the availability of additional data sources, the scientific validity of assumptions, consistency across the methodology, and appropriate presentation formats. Reviewers provided oral comments at the meeting, and written comments before and after the meeting. EPA substantially revised the HAP selection methodology in response to the reviewers' comments.

EPA also received comments from the public in response to our publication of the draft list of urban HAPs *[1]*. Consideration of issues raised by some commentors led us to modify certain aspects of both the identification methodology and the underlying data inputs. None of these changes, described in the sections below, conflicted with recommendations made earlier by the 1998 peer review panel.

In finalizing the HAP selection methodology, EPA also took the opportunity to update once again all data on emissions, ambient concentrations, health effects, and bioaccumulation potential to ensure that the selection process has relied on the most recent available information. Nevertheless, tt is important to realize that the methodology is based on databases that are far from complete, and that contain information of widely varying quality. EPA believes that this information is the best available for this purpose, and that basing its ranking on these data is reasonable. However, readers must keep in mind that substantial uncertainty surrounds this analysis. Results should be considered only relative estimates of potential hazard of various HAPs, and not construed as quantitative estimates of actual risks.

2.1 Review of Existing Studies

The first analysis of HAPs in urban areas, prepared by an EPA contractor, reviewed twenty-three existing studies of exposure, risk, or hazard associated with HAPs. These studies were conducted during recent years by EPA, state agencies, and others. Of these original twenty-three, fourteen studies were deemed appropriate for comparative ranking of HAPs. (Six assessments were dropped from consideration because they were conducted partly or entirely in rural locations, and three more were omitted because they covered fewer than ten HAPs.) Hazard ranking scores (*e.g.*, quantitative risk estimates, percent contribution to risk, ranks) from each study were normalized to the same scale, then aggregated to make a combined total score for each HAP. Carcinogens and non-carcinogens were ranked separately. Separate analyses were done for all sources combined (*i.e.*, major, area, and mobile sources), and for area sources alone. The combined analysis was the one used in the HAP selection process. HAPs that ranked above obvious breakpoints in the frequency distribution graphs from each of the four analyses were assigned highest priority. The full analysis of existing studies is presented in Appendix A.

2.2 Cumulative Exposure Project Urban Analysis

The second HAP ranking analysis was performed as part of the Cumulative Exposure Project (CEP) conducted by the EPA Office of Policy, Planning and Evaluation. The CEP urban analysis compared modeled yearly average ambient concentrations of HAPs in urban areas for 148 HAPs against risk-based concentrations (RBCs, termed "health benchmarks" by the authors) at the census tract level. A long-term Gaussian dispersion modeling approach was used, with emission rates drawn from the Toxics Release Inventory and other EPA databases, addressing major, area, and mobile sources. In the original analysis prepared by the CEP team, contributions from distant emissions of persistent pollutants and from non-anthropogenic sources were addressed with background values drawn from measurements in remote locations. The CEP compared these estimated ambient concentrations to RBCs corresponding to: (1) a one in a million upper bound lifetime cancer risk (assuming continuous exposure for 70 years), or (2) a concentration considered to have no significant risk of adverse non-cancer effects in continuously exposed populations[1]. HAPs were ranked according to the number of urban census tracts in which the modeled concentration was above the RBC. HAPs estimated to exceed their respective RBC in 50 or more urban census tracts were marked for consideration as urban HAPs.

Following the September 14, 1998 proposal on the draft integrated strategy for urban air toxics, EPA received numerous comments objecting to the CEP's use of (1) background concentrations in the HAP selection process, and (2) outdated RBCs for specific substances. To address these comments, we compared predicted ambient concentrations (omitting background) for specific HAPs with our current RBCs. These recalculations were done only for HAPs to which a background concentration was assigned in the original CEP analysis, or for which an RBC had changed.

The original CEP analysis is presented in Appendix B, and the recalculated results are presented in Appendix C.

2.3 Risk-Related Ranking Analysis

The third relative hazard analysis, prepared by EPA staff, ranked HAPs by combining surrogates for toxicity and exposure into ranking indices. The surrogates for toxicity were the risk-based concentration (RBC) for inhalation or the risk-based dose (RBD) for ingestion. For effects other than cancer, the RBC or RBD represented an exposure considered to have no significant risk of adverse non-cancer effects. For carcinogenic HAPs, RBCs or RBDs represented exposures associated with fixed levels of upper-bound predicted lifetime cancer risk. Two sets of RBCs and RBDs for carcinogens were calculated, the first at a one in ten thousand risk level and the second at one in one million. Surrogates for exposure included measured ambient concentrations, and emission rates from area, major, and mobile sources. Seven separate ranking indices were calculated, then combined into a single ranking. The risk-related ranking indices, and the process by which they were combined with results of the review of existing studies and the CEP analysis, are described below. The lists of urban HAPs and area source HAPs were developed from the results of all three analyses by considering (1) how many of the analyses identified the HAP and (2) the contribution of emissions from area sources.

2.3.1 Surrogates for Toxicity

Toxicity information used in the risk-related ranking analysis consisted of dose-response assessments

[1]An example of an estimate of "a concentration considered to have no significant risk of adverse non-cancer effects" is the EPA reference concentration (RfC). The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious non-cancer effects during a lifetime.

developed by various regulatory agencies for protection of human health. A wide variety of these assessments were incorporated, many of which were performed at different times, intended for different purposes, and subjected to varying levels of review. EPA believes this to be defensible practice for the purpose of selecting urban and area source HAPs, because the alternative to using potentially inconsistent dose-response information from non-EPA sources would be a *de facto* assumption of zero toxic potential for some substances. This practice would create false negatives that EPA considers unacceptable in this context.

All 189 HAPs originally listed under Section 112(b) of the CAAA (with the exception of radionuclides, asbestos, and fine mineral fibers) were carried through the index calculations. The remaining 186 substances and substance categories were included in the detailed calculations, even those that lacked dose-response, emission, or ambient data, and for which no indices could be calculated. (Caprolactam, recently deleted from the list of HAPs, was also included in the calculations.) EPA believes that this full presentation will allow readers to see data gaps more clearly, and may serve as a guide for future efforts to upgrade data collection for the air toxics program.

Dose-response assessments for health effects of HAPs were obtained from various sources, and prioritized according to (1) applicability, (2) conceptual consistency with EPA risk assessment guidance, and (3) level of review received. The following dose-response assessment sources were used in this analysis.

2.3.1.1 US Environmental Protection Agency (EPA)

EPA has developed chronic dose-response assessments for many of the HAPs. These assessments typically specify a reference concentration (to protect against effects other than cancer) and a unit risk (to estimate the probability of contracting cancer). A reference concentration (RfC) is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) likely to be without an appreciable risk of deleterious non-cancer effects during a lifetime. The unit risk (UR) is the upper bound excess lifetime probability of contracting cancer per microgram of HAP per cubic meter of air, assuming constant inhalation exposure over a lifetime.

EPA also publishes analogous dose-response values for oral exposure, called the reference dose (RfD) and carcinogenic potency slope (CPS). The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) likely to be without an appreciable risk of deleterious effects during a lifetime. The CPS is the upper bound excess lifetime risk of contracting cancer per milligram of HAP per kilogram body weight per day, assuming constant oral exposure over a lifetime.

In assessing a substance's carcinogenic potential, EPA evaluates various types of toxicological data and develops a "weight-of-evidence" determination. EPA's present weight-of-evidence categories are Group A (carcinogenic in humans), Group B (probably carcinogenic), Group C (possibly carcinogenic), Group D (not classifiable), and Group E (probably not carcinogenic). EPA is in the process of changing to a text-based descriptive weight-of-evidence procedure that is less categorical, but few EPA assessments reflect this change so far.

EPA disseminates dose-response assessment information in several forms, based on the level of internal review. EPA publishes dose-response assessments that have achieved full intra-agency consensus on its Integrated Risk Information System (IRIS)*[2]*. Assessments prepared by the EPA Office of Research and Development (ORD), but that have not been approved by all EPA program offices, are often published by ORD as individual health effects assessment documents. The results of many such assessments have been assembled in EPA's Health Effects Assessment Summary Tables (HEAST)*[3]*. EPA updates HEAST regularly.

2.3.1.2 Agency for Toxic Substances and Disease Registry (ATSDR)

ATSDR, which is part of the US Department of Health and Human Services, regularly publishes Health Guidelines Comparison Values (CVs) for many toxic substances. ATSDR describes CVs as media-specific concentrations to be used by health assessors to select environmental contaminants for further evaluation. They are presented with only 1 significant figure, and are considered concentrations below which contaminants are unlikely to pose a health threat. Concentrations above a CV do not necessarily represent a threat, and CVs are therefore not intended for use as predictors of adverse health effects or for setting cleanup levels.

For this analysis, the ATSDR CV of choice was the minimum risk level (MRL). An MRL is an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (other than cancer) over a specified duration of exposure. MRLs can be derived for acute, intermediate, and chronic duration exposures by the inhalation and oral routes. MRLs were chosen for use in this HAP analysis because their concept, definition, and derivation are philosophically consistent (though not identical) with the basis for EPA's RfC and RfD.

ATSDR publishes MRLs as part of toxicological profile documents, one per substance. MRLs are also collected in a table of CVs *[4]*, regularly updated and distributed by ATSDR.

2.3.1.3 California Environmental Protection Agency (CalEPA).

The CalEPA Air Resources Board has developed dose-response assessments for many HAPs, based both on carcinogenicity, and health effects other than cancer resulting from chronic and acute exposure.

The non-cancer information includes available inhalation health risk guidance values developed by USEPA or CalEPA, expressed as acute or chronic reference exposure levels (RELs). CalEPA defines the REL as a concentration level or dose at (or below) which no health effects are anticipated. Because this concept is substantially similar to EPA's non-cancer dose-response values, this analysis has used chronic RELs in the same way as RfCs and RfDs.

CalEPA's quantitative dose-response information on carcinogenicity by inhalation exposure is expressed in terms of the unit risk, defined similarly to EPA's unit risk. This analysis has used specific CalEPA URs in the same way as EPA's URs.

2.3.1.4 National Advisory Committee for Acute Exposure Guideline Levels (NAC)

USEPA's Office of Prevention, Pesticides and Toxic Substances established the NAC in 1995 to develop Acute Exposure Guideline Levels (AEGLs) and supplementary information on hazardous substances for federal, state, and local agencies and organizations in the private sector concerned with emergency planning, prevention, and response. The NAC/AEGL Committee is a discretionary Federal advisory committee that combines the efforts of stakeholders from the public and private sectors to promote efficiency and utilize sound science.

The NAC published an initial priority list of 85 chemicals for AEGL development in May 1997 and proposed AEGLs for 12 substances in October 1997 *[5]*. The AEGLs for a substance take the form of a matrix, with separate ambient levels for mild, moderate, and severe effects. Each of these three effect levels are provided for as many as four different exposure periods, typically 0.5, 1, 4, and 8 hours. Although still under public review, those proposed AEGLs for which substantial issues have not been in public comment have been considered in this analysis. AEGL values used for the HAP ranking analysis were 1-hour concentrations for the mildest available effect level.

2.3.1.5 International Agency for Research on Cancer (IARC)

The International Agency for Research on Cancer (IARC) was established in 1965 by the World Health Organization. IARC's mission is to coordinate and conduct research on the causes of human cancer, and to develop scientific strategies for cancer control. The Agency sponsors both epidemiological and laboratory research, and disseminates scientific information through meetings, publications, courses and fellowships.

As part of its mission, the IARC assembles evidence that substances cause cancer in humans and issues judgments on the strength of evidence. IARC's weight-of-evidence categories are Group 1 (carcinogenic in humans), Group 2A (probably carcinogenic), Group 2B (possibly carcinogenic), Group 3 (not classifiable), and Group 4 (probably not carcinogenic). The rankings may be applied to either single chemicals or mixtures.

IARC's weight-of-evidence for HAPs have been included in the supporting information of this analysis as a backup to EPA's weight-of-evidence determinations, which do not cover all HAPs and in some cases may be out of date.

2.3.1.6 American Industrial Hygiene Association (AIHA)

AIHA has developed emergency response planning guidelines (ERPGs) for acute exposures at three different levels of severity of health effects *[6]*. These guidelines represent concentrations for exposure of the general population for up to 1 hour associated with effects expected to be mild or transient (ERGP-1), irreversible or serious (ERPG-2), and potentially life-threatening or lethal (ERPG-3). ERPG values used for the HAP ranking analysis were for the mildest available effect level.

2.3.1.7 National Institute for Occupational Safety and Health (NIOSH)

As part of its mission to study and protect worker health, NIOSH determines concentrations of substances that are immediately dangerous to life or health (IDLHs). IDLHs were originally determined for 387 substances in the mid-1970's as part of the Standards Completion Program (SCP), a joint project by NIOSH and the Occupational Safety and Health Administration (OSHA), for use in assigning respiratory protection equipment. NIOSH is currently evaluating the scientific adequacy of the criteria and procedures used during the SCP for establishing IDLHs. In the interim, the IDLHs have been reviewed and, (if appropriate) revised. NIOSH maintains an on-line database *[7]* of IDLHs, including the basis and references for both the current and original IDLH values (as paraphrased from the SCP draft technical standards). For this HAP ranking, IDLH values were divided by 10 to more closely match the mild-effect levels developed by other sources, consistent with methodology used to develop levels of concern under Title III of the Superfund Amendments and Reauthorization Act *[8]*.

2.3.1.8 Prioritization of Sources

The risk-related ranking analysis relied on separate dose-response assessments for inhalation and oral exposure. Inhalation RBCs were developed for chronic and acute time scales, but oral RBDs were developed only for chronic exposure.

Some HAPs have been subjected to dose-response assessments by several of the regulatory agencies used as sources for this analysis. Because these assessments were done by different agencies at different times, for purposes which were similar but not identical, it is inevitable that results will not be totally consistent. To resolve inter-agency discrepancies for this analysis, EPA applied a consistent priority scheme to the universe of dose-response information.

RfCs and URs for chronic inhalation exposure obtained from EPA's IRIS database were given first priority. For HAPs lacking IRIS data, ATSDR MRLs for effects other than cancer received next preference, followed by RfCs and URs published in EPA's HEAST, then by CalEPA RELs and URs. Sources for oral RBDs were prioritized in the same order used for chronic inhalation RBCs.

For carcinogenic HAPs having no chronic inhalation assessments from any of these sources, oral CPSs were converted to URs to simulate inhalation exposure. Oral-to-inhalation conversion was not done for non-carcinogenic HAPs. EPA understands that conversion of oral dose-response information to inhalation exposure is not optimal risk assessment practice. However, the alternative to this is to omit such HAPs from the analysis altogether, based on a *de facto* assumption of zero toxicity. EPA regards this alternative as unacceptable for the purposes of urban HAP selection. This procedure carries some risk of inappropriate rankings for some HAPs.

No-effect (or minimal-effect) concentrations for acute exposure were taken first from the proposed NAC AEGLs (using the 1-hour concentration for the mildest severity level), then CalEPA acute RELs, next the AIHA ERPG (at the mildest severity), followed by the NIOSH IDLH (divided by 10). ATSDR acute MRLs were the source of last resort because they are based on 15-day exposure periods and no-adverse-effect levels, a derivation that should produce results that are fundamentally more protective than acute values from the other sources.

2.3.1.9 Assumptions on Speciation and Other Adjustments to Dose-Response Information

Following the prioritization of dose-response information, the following revisions and decisions were made, based on professional judgment:

1. *1,3-Butadiene.* On April 29, 1999, EPA's Office of Research and Development informed the Office of Air Quality Planning and Standards via memo that the UR for 1,3-butadiene currently on IRIS (2.8e-4 [$\mu g/m^3]^{-1}$) was no longer supportable. The memo recommended an interim UR (2.08e-6 [$\mu g/m^3]^{-1}$) that was more than two orders of magnitude lower (*i.e.*, less potent). Although it was too late to revise the tables and index calculations supporting the ranking to reflect this change, we confirmed that the status of 1,3-butadiene as an urban HAP would be unaffected by the revised UR.

2. *Chromium.* For chromium VI compounds, the IRIS RfC for Cr(VI) particulates was used in preference to the RfC for chromic acid mists and dissolved Cr(VI) aerosols.

3. *Chlorine.* Emissions of chlorine gas undergo a complex series of reactions in the atmosphere that

rapidly deplete the parent compound. Although this analysis was not able to consider the intricate chemistry of atmospheric chlorine, it was necessary at least to consider the lack of persistence of parent Cl_2 gas. For this reason, the IRIS RfC for hydrogen chloride was also used to represent emissions of Cl_2, which otherwise would have been over-represented in the ranking.

4. *Cobalt.* Cobalt emissions exist mostly as oxide, but the CalEPA REL and the ATSDR MRL are based on cobalt sulfate heptahydrate aerosol. These dose-response values were deemed not to match the environmental data, and were dropped.

5. *1,4-Dichlorobenzene.* In response to public comments, EPA reviewed the toxicological databases for compounds that EPA has designated as class "C" carcinogens, and for which URs are available. Data for one of these compounds, 1,4-dichlorobenzene (p-DCB), indicate that (1) metabolic activation is probably necessary for tumor formation, (2) humans metabolize p-DCB much more slowly than do mice (in which tumors were observed), and (3) normal detoxification mechanisms effectively remove low levels of carcinogenic p-DCB metabolites such as humans might produce. Because of these uncertainties this analysis did not use a UR for p-DCB. Available URs for other class "C" carcinogens were retained.

6. *Glycol Ethers.* Five different glycol ether compounds had available dose-response assessments that provided recommended RfCs or equivalent levels. The lowest of these (*i.e.,* the most protective) was applied to the entire category.

7. *Lead.* For lead and compounds, the CalEPA UR was used for carcinogenic effects and the EPA national ambient air quality standard was used in lieu of an RfC for non-cancer effects.

8. *Mercury.* The IRIS RfC for elemental mercury was applied to inhalation of mercury and compounds, based on the finding of EPA's Mercury Report *[9]* that the dominant form of mercury in the atmosphere is elemental (although divalent Hg may exist near some sources.) The IRIS RfD for methyl mercury was used for food chain calculations, to reflect that compound's bioaccumulation potential.

9. *Nickel.* The IRIS unit risk for nickel inhalation was based on carcinogenic effects of insoluble nickel compounds in crystalline form. Soluble nickel species, and insoluble species in amorphous form, do not appear to produce genotoxic effects by the same mechanism as insoluble crystalline nickel. Available nickel speciation information for some of the largest nickel-emitting sources (including oil combustion, coal combustion, and others) suggests that at least 35% or more of total nickel emissions are soluble compounds. Of the insoluble nickel emissions, 17% is thought to be oxides, 3% or more sulfidic, and the rest is unknown. Based on these data, this analysis has assumed that 50% of emitted nickel is insoluble, and that 50% of insoluble nickel is crystalline. On this basis, the UR for nickel subsulfide (representing pure insoluble crystalline nickel) was divided by 4 and applied to all nickel compounds.

10. *Phosphorus.* Dose-response assessment values for white phosphorus, which can exist only momentarily in the presence of oxygen, were deemed inappropriate to apply to phosphorus emission or monitoring data, and were dropped.

11. *Polycyclic Organic Matter.* The analysis used a group of 7 carcinogenic PAH compounds (benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene,

dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) to represent the entire polycyclic organic matter (POM) HAP category. A weighted UR of 3.3e-4 $(ug/m^3)^{-1}$ was developed for these carcinogenic PAH compounds tracked as a group by EPA's National Toxics Inventory (described below). The UR was based on a combination of compound-specific UR values *[10]*, and the inventory emissions for each of the compounds.

12. *Selenium.* The CalEPA chronic REL for hydrogen selenide was deemed inappropriate to apply to all selenium compounds, based on ATSDR's judgment *[11]* that fossil fuel combustion is the primary source of atmospheric Se, which is emitted predominantly as SeO_2. No inhalation RBC was used.

13. *Vinyl Chloride.* The IRIS UR for vinyl chloride is also currently under review. Although this analysis uses the older UR currently on IRIS, we confirmed that the status of vinyl chloride as an urban HAP would not be affected by the draft reassessment.

The complete set of regulatory dose-response information used in the risk-related ranking analysis is presented in Table 1, together with the EPA and IARC weight-of-evidence determinations for carcinogenicity and the source of each regulatory value. All HAPs (plus caprolactam) appear in this table, with blanks showing where dose-response assessments were not available. Ranking indices could not be calculated for these substances.

2.3.1.10 Development of Risk-Based Concentrations (RBCs) and Risk-Based Doses (RBDs)

RBCs *[12]* and RBDs are a simple device by which dose-response information for cancer and non-cancer effects can be reduced to a single type of information—an ambient air concentration (or oral dose) of a substance that defines an insignificant health risk over a specified exposure period. Concentrations or doses lower than the RBC/RBD can usually be ignored. Higher concentrations or doses do not necessarily equate to a significant threat, but may deserve a closer look.

RBCs and RBDs are products of risk assessments run in reverse. Instead of beginning with environmental concentrations and applying an exposure scenario to calculate a risk, the risk assessor begins with a fixed level of risk and inverts the calculations to determine the environmental concentration of a substance that will produce it. Such inverted calculations, when performed in accordance with EPA's national risk assessment guidelines, are no less valid than the usual forward computation of risk. The selection of a fixed risk level, however, may appear to imply a policy choice that is not intended.

For non-cancer effects, the RBC/RBD was simply the reference concentration or reference dose (or similar value from another source). For non-threshold carcinogens, the RBC/RBD was based on a fixed, nonzero level of risk selected to reflect the range of risk levels that EPA generally uses in risk-based decision-making. For example, a maximum individual risk for cancer of 1 in 10,000 (1e-4) is generally the upper end of the range of acceptability. However, in risk-based decision-making EPA also may attempt to reduce excess individual cancer risks below 1 in 1 million (1e-6) for the greatest possible number of people. This range of risk targets is not absolute, however. Each risk reduction decision is tailored to its specific situation, taking into account additional factors such as the number of people affected, type of cancer, uncertainty in the assessment, costs of controls, economic impacts, technical feasibility, legal requirements, and public acceptance of various levels of risk. Thus, some risk management decisions may fall outside the 1e-4 to 1e-6 risk range.

In selecting HAPs for the urban strategy, it was necessary to combine scoring for carcinogenic HAPs (based on RBC/RBDs calculated to a risk range) with that for non-carcinogenic HAPs (based on RBC/RBDs calculated at exposure levels below the threshold for adverse effects). This was accomplished by calculating two sets of chronic RBC/RBDs, called "case 1" and "case 2". The case 1 concentration or dose was that yielding a 1e-6 upper-bound lifetime cancer risk, or the RfC for chronic non-cancer effects, whichever was lower. The case 2 concentration or dose represented a 1e-4 upper-bound lifetime cancer risk, or the RfC, whichever was lower. For HAPs having only a UR and no RfC, there was a 100-fold difference between case 1 and case 2. For HAPs having only an RfC and no UR, case 1 and case 2 were identical. For HAPs with both a UR and RfC, case 1 was often (though not always) based on cancer and case 2 on non-cancer effects.

Exposure assumptions were deliberately kept simple and minimal. Inhalation RBCs for chronic exposure were based on an assumption of continuous lifetime exposure. Inhalation RBCs for acute exposure were based on episodic 1-hour exposures with enough recovery time between exposures to preclude lingering adverse effects. RBDs for chronic oral exposure, expressed as mg of HAP ingested per kg of body mass per day (mg/kg/d), were used directly without exposure assumptions. RBCs and RBDs for case 1 and case 2 are presented in Table 2.

EPA recognizes that actual exposures to HAPs are far more complex, and that these minimalist exposure scenarios, if used for quantitative risk assessment, could produce misleading results. Readers are reminded that this analysis is not intended to quantify absolute levels of risk, but rather to rank HAPs according to *relative* hazard. Applying a more detailed and realistic exposure assessment to this analysis would drastically increase the complexity of the ranking analysis, but whether this additional complexity would greatly alter the overall list of priority HAPs is unclear.

2.3.1.11 Uncertainties in Use of Dose-Response Surrogates

2.3.1.11.1 Carcinogens

EPA's methods for deriving URs and oral potency slopes were intentionally designed to avoid underestimation of cancer risk. This protectiveness was incorporated into several steps of the process. First, potency estimates for most HAPs were based on a mathematical model (the linearized multistage model) that assumes a straight-line dose-response all the way from administered doses in animals to zero dose. In effect, the model predicts that any dose of a carcinogen, however small, carries some minute lifetime cancer risk. EPA uses this model as its protective default in the absence of information supporting a different model for a substance. Use of other less conservative models would produce lower ranks for many carcinogens relative to non-carcinogens.

Carcinogenic potency estimates for many HAPs also incorporate protective extrapolations from test animals to humans, based on relative surface area (assumed to be the 0.67 power of body mass) as a surrogate for metabolic rate. It can also be argued, for example, that animal data can be converted to human equivalence using body mass itself (i.e., the 1.0 power of body mass), which is less protective. EPA itself is changing to a conversion based on relative basal metabolic rate (assumed to be the 0.75 power of body mass). Use of a higher power of body mass would produce lower ranks for carcinogens relative to non-carcinogens.

Third, carcinogenic potency estimates for most HAPs are 95% upper confidence limits rather than best estimates. The true potencies may be less, but are unlikely to be greater.

2.3.1.11.2 Non-carcinogens

RfCs and oral RfDs define continuous lifetime exposures, with uncertainty spanning perhaps an order of magnitude, that EPA expects to be safe for human populations. RfCs and RfDs often must be based on limited data, and may be well below the actual human threshold for adverse effects, for two reasons. First, EPA favors the most sensitive species and the adverse effect to that species which occurs at the lowest dose. Although extrapolations from animals to humans are based on the best available data, in some cases EPA assumes that humans may be up to ten times more sensitive than the tested species, and that sensitive humans may be up to ten times more sensitive than the average human. These assumptions, designed to give the benefit of uncertainty to the exposed public, may produce RfCs and RfDs that are well below the true human adverse-effect thresholds for some HAPs.

Second, EPA has based some RfCs and RfDs on the no observed adverse effect level (NOAEL). The NOAEL is the highest dose at which test animals did not exhibit adverse effects relative to controls. Because most toxicological studies are designed with considerable gaps between test doses, the true threshold for adverse effects may be substantially higher than the experimental NOAEL. Use of the NOAEL instead of the true threshold for effects provides an additional level of protectiveness in reference doses.

2.3.1.11.3 Adaptation of Oral Dose-Response Assessments to Inhalation

Additional uncertainty was introduced for 15 carcinogenic HAPs and HAP categories (out of the total 188) that lacked dose-response assessments for inhalation, but had oral values. For these HAPs, EPA judged that a converted oral value was preferable to the alternative *de facto* assumption of zero carcinogenic potential. Conversion from oral to inhaled exposure was based on an assumed body mass of 70 kg and inhalation rate of 20 m^3/d. No adjustment was applied to account for differences in absorption through the GI tract and the lung, or for possible direct adverse effects to the lung. There is no way of knowing if "quasi" RfCs and URs derived by oral-to-inhalation conversions are more or less protective than fully-developed ones.

2.3.1.11.4 Prioritizing Dose-Response Assessments

While dose-response assessments developed by EPA, ATSDR, CalEPA, and others share substantially the same purpose and philosophy, these factors are not identical. If EPA were to develop a complete set of RfCs and URs for all HAPs, it is possible that some would be significantly different than the non-EPA values actually used.

CalEPA has proposed URs for six HAPs or HAP categories that lack both an EPA and IARC weight-of-evidence determination. This ranking analysis has used these URs. Leaving them out would move these substances lower in the ranking, and would eliminate some entirely. Use of these six URs in this analysis does not constitute a recommendation by EPA that they are necessarily appropriate to use in quantitative risk assessments.

This analysis used a somewhat different prioritization scheme than did the EPA Cumulative Exposure Project (CEP). The major differences were that the CEP (1) did not use EPA Superfund Technical Support values at all, (2) did not extrapolate from oral to inhalation exposure for noncarcinogens, (3) used older CalEPA assessments, and (4) included assessments from unpublished 1994 draft EPA guidance for determining *de minimis* risk levels.

In assessing acute hazards, the CEP divided SARA LOCs by a factor of 1000 to simulate no-effect levels, whereas the risk-related ranking analysis used ATSDR acute RELs, followed by NAC AEGLs, with unaltered LOCs serving only as a last resort. As a result of its treatment of LOCs (and their subsequent comparison to yearly average concentrations, rather than short-term averages) the CEP produced more protective acute results for some HAPs than did the risk-related ranking indices. EPA has determined that the outcome of the analysis—the proposed list of 30 substances—was not influenced by the CEP's high level of protectiveness for acute effects.

These differences in assessment prioritization resulted partly from the fact that the CEP had somewhat different goals than did the present analysis. Mostly, however, these variations arose from the fact that there is no clear "best" way to prioritize dose-response assessments. Two groups of scientists independently addressed a fuzzy issue, and arrived at somewhat different answers. EPA believes that the HAP selection process will be strengthened, rather than weakened, by this dichotomy of opinion.

2.3.2 Surrogates for Exposure

The second major part of the HAP ranking indices (the first part being the dose-response data described in the previous section) was information on exposure. Actual data describing human exposure to HAPs are limited, and lack the comprehensive geographic, temporal, and multi-contaminant coverage that this ranking exercise requires. Therefore, EPA chose to base the ranking on exposure surrogates—data related to, but not identical with, exposure. The two types of exposure surrogates chosen were (1) long- and short-term ambient air quality measurements in urban areas, and (2) estimated annual masses of HAPs released in urban areas by major, area, and mobile sources.

2.3.2.1 Measured Concentration Data

The ambient air quality dataset used in this analysis was created by combining all available monitoring data from EPA's Aerometric Information Retrieval System (AIRS) and Toxics Data Archive (9/30/98 version) databases for the 188 compounds defined in the Clean Air Act as hazardous air pollutants. The analysis was restricted to data collected in urban areas from 1988 through 1997. Data were expressed in units of micrograms per cubic meter ($\mu g/m^3$). Concentration data that were below the minimum detection limit (MDL) were replaced by ½ the MDL before averaging. When the MDL was missing, the lowest reported value was assumed a plausible value for the MDL.

For input to the chronic exposure indices, selected ambient air quality data were first averaged arithmetically for each combination of day, HAP, and monitoring site. Annual averages were then calculated from the daily averages. Data were selected for inclusion where (1) short-term measurements for at least 75% of the hours in a day, and (2) daily averages for at least 75% of the days in a year, were available. The expected number of daily measurements corresponding to 100% completeness was estimated by determining the frequency distribution of sampling intervals (days) and dividing 365 by the mode of the distribution.

Annual average concentrations from 1988 to 1997 for each site-pollutant combination were next averaged across years. Finally, the resulting multi-year average concentrations were averaged across monitoring sites into a single long-term multi-city average concentration for each HAP for which data met the selection criteria. The criterion for multiyear statistics was 75% completeness for 75% of the years. HAPs for which more than 90% of reported results were below the MDL were dropped from the analysis. Ambient data for individual compounds in the "7-PAH" group (*i.e.*, benz[a]anthracene, benzo[a]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, and indeno(1,2,3-cd)pyrene) were summed and entered on the 7-PAH line.

To simulate acute exposure for each HAP, the 95th percentile of the original dataset was selected. EPA judged that this concentration represented a reasonable maximum short-term exposure, while avoiding potential problems with outliers that could result if higher percentiles were used.

The ambient concentration data used in the ranking analysis are presented in Table 3. All HAPs were included in the table, with missing ambient concentration data shown as blanks. Ranking indices based on ambient concentrations could not be calculated for these substances lacking these data.

2.3.2.2 Emission Mass Data

The second type of data used in this ranking analysis as a surrogate for exposure were estimated emitted masses of individual HAPs. These data were obtained from several EPA emission data sources, for the period from 1990 to 1993 (the "baseline year" for measuring risk reductions). Data were retrieved for counties that contained a metropolitan statistical area (MSA) of 250,000 people ("urban-1"), or (for counties lacking an MSA of 250,000) a population designated as more than 50% urban by the Bureau of Census ("urban-2"). Data for counties classified as "rural" were excluded. Retrievals contained emissions from all types of sources, including major, area, and mobile sources.

Emission data were retrieved from the four sources described in Exhibit 1, below.

Exhibit 1. Emission data sources used in HAP ranking analysis, in order of preference. Data from lower-priority sources were used only if information from a higher-priority source was not available.

Inventory Data Source	Date Available	HAP Estimates Used in Urban Analyses	Comments
1. 1990 Emissions Inventory of Forty Potential Section 112(k) Pollutants *[13]*	March 1999	- 40 candidate urban HAPs - National level emissions split into urban/rural county designations	- Best source for 40 HAP emissions, estimation technique documentation, urban/rural splits and definitions - Publicly available.
2. Updated inventory for two section 112(c)(6) HAPs *[14]*	March 1999	- PCB and HCB estimates were updated from the 4/97 112(c)(6) inventory - Urban/rural splits not included in database, but developed by EPA contractor for this analysis.	- Most recent data set for these 2 HAPs - Not documented or publicly available - Changes primarily reflect new data from MACT standard development
3. 1993 NTI version 9801 (revised)	February 1999	- 188 individual HAPs and category totals - Urban/rural splits not included in database, but developed by EPA staff for this analysis.	- Most recent compiled data set for HAPs not in 40-HAP inventory or 112(c)(6) update. - Publicly available on CD by written request.
4. 1993 NTI	October	- Any included speciated	- Only compiled data for individual

Inventory Data Source ...	Date Available	HAP Estimates Used in Urban Analyses	Comments
version 9702 *[15]*	1997	HAPs (e.g., individual POM compounds) - Urban/rural splits not included in database, but developed by EPA staff for this analysis.	species within HAP categories. - Individual species estimates are artifacts of primary data sources (e.g., States or TRI). Estimates for these individual species are not reported consistently and are likely to under-represent national totals. - Superseded by version 9801, which lacks speciated data; no longer available.

Emission data used in ranking index calculations are shown in Table 3. HAPs for which information was not available from the emission databases described above were included in this table as blanks, and emission-based indices for these substances were not calculated.

2.3.2.3 Speciation Assumptions for Inventory and Ambient Monitoring Data

The following decisions were made regarding the use of NTI emission data, based on staff judgment:

1. *Antimony.* Emission and ambient data for antimony were assumed to represent the carcinogenic trioxide, which is thought to be the predominant form of atmospheric antimony *[16]*.

2. *Arsenic.* Emission and ambient data for arsenic, which is released to the air mainly as arsenic trioxide and is usually found in the atmosphere as a mixture of particulate arsenite and arsenate *[17]*, were evaluated as inorganic arsenic.

3. *Chromium.* Emission data for total chromium, which did not distinguish between the III and VI valences, were apportioned to reflect a 35% reported proportion of chromium VI *[18]*.

4. *Lead.* Emission and ambient data for total lead were assumed to be inorganic, and paired with health RBC/RBDs for inorganic lead. Emission data for alkylated lead were paired with RBC/RBDs for tetraethyl lead in the index calculations. Alkylated and inorganic lead were scored separately.

5. *Mercury.* Emissions and ambient air concentrations of mercury were presumed to be elemental mercury, the dominant form of mercury in the atmosphere *[9]*.

6. *Polycyclic Organic Matter.* Emission and ambient data for a group of 7 carcinogenic PAH compounds (benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) were used to represent the entire polycyclic organic matter (POM) HAP category. These data were paired with a weighted UR developed for these compounds, described in section 2.3.1.9.

2.3.2.4 Bioconcentration Data

The bioaccumulation factor (BAF) and bioconcentration factor (BCF) are estimates of the ratio of the concentration of a substance that an organism will accumulate in its tissues relative to the concentration of the substance in the environment, at equilibrium. The previous draft of the risk-related ranking analysis used a database of these values obtained from the 1997 beta test version of EPA's Waste Management Prioritization Tool (WMPT). EPA received several comments noting that these BAFs and BCFs were incomplete and of inconsistent quality, and further comments requesting a more complete treatment of bioaccumulative HAPs in general. We have partially addressed these concerns by replacing the 1997 WMPT data with the database of BAFs and BCFs from EPA's recently-released 1999 version of the WMPT *[19]*, which has been substantially expanded and improved.

The WMPT is intended to allow EPA to rank relative hazards from the list of hazardous substances regulated under the Resource Conservation and Recovery Act, and was judged to be the most comprehensive source of high-quality information for the purpose of HAP ranking. The present analysis follows the WMPT's preferences for BAFs over BCFs, and for measured values over predicted values. Among the 7 PAH compounds grouped as the POM surrogate for this analysis, measured BAFs were available only for chrysene and benz[a]anthracene. EPA assigned this measured BAF value (800 for both compounds) to the entire 7-PAH group.

BCF/BAFs used in this ranking analysis are presented in Table 3.

2.3.2.5 Uncertainties in Use of Exposure Surrogates

This analysis has the following important limitations: (1) the ranking is relative rather than absolute, (2) the results cannot be interpreted as quantitative risk estimates, and (3) the emission and ambient concentration data bear some relation to human exposure, but cannot themselves be construed as exposure estimates.

The ambient monitoring database had many gaps, shown as blanks in Table 3. No measurements exist for many urban locations, and locations that were monitored were usually sampled for only a few HAPs. Measurements that do exist were taken only at specific locations and times, and cannot represent the whole spectrum of ambient concentrations. Furthermore, even perfectly accurate ambient concentrations cannot fully explain human exposure, which is influenced by complex behaviors. Finally, the ambient air measurements are subject to the same limitations as all measured data—detection limits that may be too high, and potential for errors in sampling, analysis, and reporting of data.

Most NTI emission data are from 1990, with updated information for some HAPs in some locations for 1993. This database was used to reflect a 1990 baseline, the year the Act was passed, as a baseline from which to measure future improvements, and it should not be interpreted as representing current conditions. Most emission data are predicted from emission factors and activity levels, both of which are subject to error. Even perfectly accurate emission data would be a substantially inaccurate predictor of ambient concentrations, which are also influenced by factors such as proximity of populations, site-specific parameters like stack height, meteorological conditions, atmospheric transformation of HAPs, and non-source-related background concentrations.

2.3.3 The HAP Ranking Process

Although the CAAA requires EPA to develop a single list of HAPs of concern for the urban strategy, EPA judged that this list should appropriately reflect a variety of possible exposure periods, pathways, and types of adverse health effect. Accordingly, we chose a multi-faceted approach designed to rank distinctly different types of hazard. Four distinct ranking indices (described in detail below) were calculated for each HAP, data permitting. Each index was designed to utilize a different exposure surrogate and to reflect a specific type of concern. Three of these indices were based on chronic exposure, and one on acute exposure. The three chronic indices were calculated using case 1 and case 2 dose-response information (described above). The total number of calculated "sub-indices" was seven.

Each of these calculated indices represents only a simple surrogate measure of relative hazard that cannot be translated to absolute risk. Index values can be most accurately described as ambient concentrations and emission masses that have been adjusted to account for relative differences in the toxicity of various HAPs. They provide no information about whether emissions, ambient levels, or risks are acceptable or unacceptable.

2.3.3.1 Index 1: Ambient/Acute

The ambient acute index was calculated by dividing the 95th percentile 24-hour concentration of each HAP by its risk-based concentration for acute effects. This index reflects the potential of HAPs to present short-term non-cancer hazards by inhalation.

2.3.3.2 Index 2: Ambient/Chronic

The ambient chronic index was calculated by dividing the long-term average ambient concentration of each HAP by its risk-based concentration for chronic effects. This was done separately for case 1 (RBC set at 1e-6 risk or the RfC, whichever was lower) and case 2 (RBC set at 1e-4 risk or the RfC, whichever was lower). Case 1 and case 2 of this index reflect potential long-term carcinogenic and non-carcinogenic hazards, respectively, by the inhalation exposure pathway, based on measured ambient concentration data.

2.3.3.3 Index 3: Emission/Chronic/Inhalation

The NTI emission rate, in tons per year, was adjusted by dividing it by the RBC for chronic effects. As with the ambient chronic index, this was done separately for case 1 (RBC set at 1e-6 risk or the RfC, whichever was lower) and case 2 (RBC set at 1e-4 risk or the RfC, whichever was lower). Case 1 and case 2 of this index reflect potential long-term carcinogenic and non-carcinogenic hazards, respectively, by the inhalation exposure pathway, based on emission data. Although emission data represent a less direct surrogate for exposure than ambient data do, this index is valuable because the emission database is far more complete in terms of numbers of HAPs and locations considered.

2.3.3.4 Index 4: Emission/Chronic/Oral

The NTI emission rate, in tons per year, was adjusted by multiplying it by the bioconcentration factor and dividing it by the oral risk-based dose (RBD) for chronic effects. As with the other chronic indices, this was done separately for case 1 (RBD set at 1e-6 risk or the RfD, whichever was lower) and case 2 (RBD set at 1e-4 risk or the RfD, whichever was lower). Case 1 and case 2 of this index reflect potential long-term carcinogenic and non-carcinogenic hazards, respectively, by non-inhalation exposure pathways (*e.g.,* food-chain bioaccumulation) based on emission data.

2.4 Combination of Individual Ranking Indices

Because the sub-indices were developed from different types of exposure surrogates, their measurement units were not compatible with summing or averaging. Therefore, it was necessary to normalize the index values before combining them into a single ranking. Raw scores (Table 4) were normalized to a scale of 0-100 within each sub-index (Table 5), with 100 representing the most hazardous score and 0 representing no hazard. Scores that could not be calculated because of missing data were treated as blanks, not as zeros.

This system of normalizing sub-index scores to the same 0-100 scale was adopted in response to comments received on the September 1998 proposed HAP selection protocol. The earlier normalization method ranked HAPs within each sub-index, then averaged the ranks. Commentors noted that this method obscured quantitative differences in magnitude among HAPs, and artificially increased the importance of sub-indices having the fewest calculated results.

EPA agreed with these comments, and revised the normalization methodology. The use of a 0-100 scale preserves differences in relative magnitude of hazards. For example, if the highest-scoring HAP has a raw index score ten times higher than the second HAP, the two HAPs would have been ranked 1 and 2 under the old system. Under the new system, their normalized scores would be 100 and 10. The system also treats all sub-indices equally, regardless of how many HAPs are scored. For example, under the old system only about 20 HAPs could be scored for the ambient/acute index[2], so the least hazardous HAP had a rank of about 20. However, more than 150 HAPs were scored for the emission/chronic/inhalation index. Thus, the HAP that ranked 20th out of 150 in this index was probably much more important than the HAP ranking 20th of 20 in the ambient/acute index. This system artificially deflated the importance of data-rich sub-indices for which many HAPs were scored. The new scoring system removes this artificial bias.

Normalized scores for each HAP were averaged across the seven sub-indices. This represented a substantial change from the September 1998 HAP selection protocol, which combined sub-indices by averaging their ranks and thereby preserved the bias (described above) toward sub-indices with the least data. The revised method treats all seven sub-indices as equally important. This equal-weighting system was used because we judged that information on HAP exposures on the national scale was not yet sufficient to support a different relative weighting scheme. This limitation of the available data is described more fully in section 1, which explains how the hazard ranking approach was selected specifically because HAP exposures are largely unknown. If data were sufficient to determine the relative magnitude of risks associated with chronic vs. acute exposures, cancer vs. non-cancer effects, and contact by inhalation vs. ingestion, it would likely have also been possible to develop a national screening-level risk assessment as the basis for selecting HAPs.

Average scores and the overall HAP rank are shown in Table 5. Figures 1 and 2 show the 60 HAPs that ranked highest in this exercise, sorted in order of average score. Individual sub-index scores appear as points on these figures, except for blanks caused by data gaps.

3. Results and Selection of HAPs Proposed for Listing

Results for all three ranking analyses—(1) the risk-related ranking indices, (2) the CEP urban analysis, and (3) the review of existing risk assessments and hazard rankings—are combined and summarized in Table 6. In selecting the urban HAPs for the integrated strategy, we compared the results of the three separate analyses, and selected those HAPs for which a publicly reviewed baseline national

[2] Note: In the revised HAP ranking, we have been able to score over 50 HAPs for the ambient/acute index.

emissions inventory was available (under CAA section 112(k) or 112(c)(6)), and which was either:

1. Identified by at least two of the three analyses (regardless of area source contribution), or

2. Identified by at least one of the three analyses, with an area source contribution to total emissions of at least 25 percent.

This second criterion was set in recognition of the area source emphasis of this integrated strategy. These criteria produced an integrated list of 33 "urban HAPs" (Table 6). Section 112(k) of the CAA requires us to identify not less than 30 "area source HAPs" that pose the greatest threat to public health in the largest number of urban areas, as the result of emissions from area sources.

To identify these 30 area source HAPs, we ranked the list of 33 urban HAPs by percent contribution to national urban emissions from area sources and selected the 30 urban HAPs with the greatest area source contributions. The remaining three urban HAPs (coke oven emissions, 1,2-dibromoethane, and carbon tetrachloride) have less significant emissions contributions from area sources, and are not among the 30 area source HAPs considered for area source category listing.

4. References

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Table 1. Dose-response assessment information, with sources, used for ranking.

HAP No.	Contaminant	CAS #	Weight of Evidence EPA	Weight of Evidence IARC	Chronic Inhalation Reference mg/m3	Inhalation Reference Dose mg/kg/d	Oral Reference Dose mg/kg/d	Inhalation Unit Risk m3/ug	Inhalation Potency Slope kg-d/mg	Oral Potency Slope kg-d/mg	Acute Inhalation Reference mg/m3
1	Acetaldehyde	75070	B2	2B	0.009 IR	-	-	2.2E-006 IR	-	1.00E-02 CA	18 AI
2	Acetamide	60355	-	2B	-	-	-	2E-005 CA	-	7.00E-02 CA	-
3	Acetonitrile	75058	-	-	0.05 HE	1.43E-02 HE	6.00E-03 IR	-	-	-	84 NI
4	Acetophenone	98862	D	-	-	-	1.00E-01 IR	-	-	-	-
5	2-Acetylaminofluorene	53963	-	-	-	-	-	-	-	-	-
6	Acrolein	107028	C	3	2E-005 IR	-	5.00E-04 AT	-	-	-	0.0004 CA
7	Acrylamide	79061	B2	2A	0.0007 CA	-	2.00E-04 IR	1.30E-03 IR	-	4.50E+00 IR	6 NI
8	Acrylic acid	79107	-	-	0.001 IR	-	5.00E-01 IR	-	-	-	6 CA
9	Acrylonitrile	107131	B1	2A	0.002 IR	-	4.00E-02 AT	6.8E-005 IR	-	5.40E-01 IR	22 AI
10	Allyl chloride	107051	C	3	0.001 IR	-	-	6E-006 CA	-	2.10E-02 CA	9.4 AI
11	4-Aminobiphenyl	92671	-	1	-	-	-	-	-	-	-
12	Aniline	62533	B2	3	0.001 IR	-	-	1.6E-006 CA	-	5.70E-03 IR	30 NA
13	o-Anisidine	90040	-	2B	-	-	-	-	-	-	5 NI
14	Asbestos*	1332214	A	1	-	-	-	-	-	-	-
15	Benzene	71432	A	1	0.06 CA	-	-	7.80E-06 IR	-	2.90E-02 IR	0.8 CA
16	Benzidine	92875	A	-	0.01 CA	-	3.00E-03 IR	6.70E-02 IR	-	2.30E+02 IR	-
17	Benzotrichloride	98077	B2	2B	-	-	-	3.70E-03 CO	-	1.30E+01 IR	-
18	Benzyl chloride	100447	B2	2B	-	-	-	4.9E-005 CA	-	1.70E-01 IR	0.5 CA
19	1,1-Biphenyl	92524	D	-	-	-	5.00E-02 IR	-	-	-	-
20	Bis(2-ethylhexyl)phthalate (DEHP)	117817	B2	2B	0.01 CA	-	2.00E-02 IR	2.4E-006 CA	-	1.40E-02 IR	-
21	Bis(chloromethyl)ether	542881	A	1	-	-	-	6.20E-02 IR	-	2.20E+02 IR	-
22	Bromoform (tribromomethane)	75252	B2	3	-	-	2.00E-02 IR	1.1E-006 IR	-	7.90E-03 IR	880 NI
23	1,3-Butadiene	106990	B2	2A	0.008 CA	-	-	2.80E-04 IR	-	3.40E+00 CA	22 AI
24	Calcium cyanamide	156627	-	-	-	-	-	-	-	-	-
25	Caprolactam	105602	-	-	-	-	5.00E-01 IR	-	-	-	-
26	Captan	133062	B2	3	-	-	1.30E-01 IR	1E-006 CO	-	3.50E-03 HE	-
27	Carbaryl	63252	-	-	-	-	1.00E-01 IR	-	-	-	10 NI
28	Carbon disulfide	75150	-	-	0.7 IR	-	1.00E-01 IR	-	-	-	20 CA
29	Carbon tetrachloride	56235	B2	2B	0.04 CA	-	7.00E-04 IR	1.5E-005 IR	-	1.30E-01 IR	5 CA
30	Carbonyl sulfide	463581	-	-	-	-	-	-	-	-	-
31	Catechol	120809	-	-	-	-	-	-	-	-	-
32	Chloramben	133904	-	-	-	-	1.50E-02 IR	-	-	-	-
33	Chlordane	57749	B2	2B	0.0007 IR	-	5.00E-04 IR	1.00E-04 IR	-	3.50E-01 IR	10 NI
34	Chlorine	7782505	-	-	0.02	-	1.00E-01 IR	-	-	-	2.9 NA
35	Chloroacetic acid	79118	-	-	-	-	2.00E-03 HE	-	-	-	-
36	2-Chloroacetophenone	532274	-	-	3E-005 IR	-	-	-	-	-	-

Table 1. Dose-response assessment information, with sources, used for ranking.

HAP No.	Contaminant	CAS #	Weight of Evidence EPA	Weight of Evidence IARC	Chronic Inhalation Reference mg/m3	Inhalation Reference Dose mg/kg/d	Oral Reference Dose mg/kg/d	Inhalation Unit Risk m3/ug	Inhalation Potency Slope kg-d/mg	Oral Potency Slope kg-d/mg	Acute Inhalation Reference mg/m3
37	Chlorobenzene	108907	D	-	0.02 HE	5.71E-03 HE	2.00E-02 IR	- -	- -	- -	460 NI
38	Chlorobenzilate	510156	-	-	- -	- -	2.00E-02 IR	7.7E-005 HE	2.70E-01 HE	2.70E-01 HE	- -
39	Chloroform	67663	B2	2B	0.098 AT	- -	1.00E-02 IR	2.3E-005 IR	- -	6.10E-03 IR	0.4 CA
40	Chloromethyl methyl ether	107302	A	1	- -	- -	- -	- -	- -	- -	- -
41	2-Chloro-1,3-butadiene (chloroprene)	126998	-	-	0.007 HE	2.00E-03 HE	2.00E-02 HE	- -	- -	- -	110 NI
42	Cresols/cresylic acid (isomers and mixture)	1319773	C	-	0.004 CA	- -	- -	- -	- -	- -	110 NI
43	2-Methylphenol (o-cresol)	95487	C	-	- -	- -	5.00E-02 IR	- -	- -	- -	110 NI
44	3-Methylphenol (m-cresol)	108394	C	-	- -	- -	5.00E-02 IR	- -	- -	- -	110 NI
45	4-Methylphenol (p-cresol)	106445	C	-	- -	- -	5.00E-03 HE	- -	- -	- -	110 NI
46	Cumene	98828	D	-	0.4 IR	- -	1.00E-01 IR	- -	- -	- -	440 NI
47	2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757	-	-	- -	- -	1.00E-02 IR	- -	- -	- -	10 NI
48	DDE	72559	B2	-	- -	- -	- -	9.7E-005 CO	- -	3.40E-01 IR	- .
49	Diazomethane	334883	-	-	- -	- -	- -	- -	- -	- -	- -
50	Dibenzofuran	132649	-	-	- -	- -	- -	- -	- -	- -	- -
51	1,2-Dibromo-3-chloropropane	96128	B2	-	0.0002 IR	- -	- -	6.9E-007 HE	2.42E-03 HE	1.40E+00 HE	- -
52	Dibutyl phthalate	84742	D	-	- -	- -	1.00E-01 IR	- -	- -	- -	400 NI
53	1,4-Dichlorobenzene	106467	C	2B	0.8 IR	- -	- -	- -	- -	2.40E-02 HE	90 NI
54	3,3'-Dichlorobenzidine	91941	B2	2B	- -	- -	- -	3.40E-04 CA	- -	4.50E-01 IR	- -
55	Bis(2-chloroethyl)ether	111444	B2	-	- -	- -	- -	3.30E-04 IR	- -	1.10E+00 IR	58 NI
56	1,3-Dichloropropene	542756	B2	2B	0.02 IR	- -	3.00E-04 IR	3.7E-005 HE	1.30E-01 HE	1.80E-01 HE	- -
57	Dichlorvos	62737	B2	2B	0.0005 IR	- -	5.00E-04 IR	8.3E-005 CO	- -	2.90E-01 IR	10 NI
58	Diethanolamine	111422	-	-	0.02 CA	- -	- -	- -	- -		- -
59	N-N-Dimethylaniline	121697	-	3	- -	- -	2.00E-03 IR	- -		- -	50 NI
60	Diethyl sulfate	64675	-	2A	- -	- -	- -	- -		- -	- -
61	3,3'-Dimethoxybenzidine	119904	B2	2B	- -	- -	- -	4E-006 CO	- -	1.40E-02 HE	- -
62	p-Dimethylaminoazobenzene	60117	-	-	- -	- -	- -	1.30E-03 CA	- -	4.60E+00 CA	- -
63	3,3'-Dimethylbenzidine	119937	B2	-	- -	- -	- -	2.60E-03 CO	- -	9.20E+00 HE	- -
64	Dimethyl carbamoyl chloride	79447	-	-	- -	- -	- -	- -	- -	- -	- -
65	N,N-Dimethylformamide	68122	-	2B	0.03 IR	- -	1.00E-01 HE	- -	- -	- -	6 AI
66	1,1-Dimethylhydrazine	57147	B2	2B	- -	- -	- -	- -	- -	- -	7.4 NA
67	Dimethyl phthalate	131113	D	-	- -	- -	- -	- -	- -	- -	200 NI
68	Dimethyl sulfate	77781	B2	2A	- -	- -	- -	- -	- -	- -	3.6 NI
69	4,6-Dinitro-2-methylphenol	534521	-	-	- -	- -	- -	- -	- -	- -	0.5 NI
70	2,4-Dinitrophenol	51285	-	-	- -	- -	2.00E-03 IR	- -	- -	- -	- -
71	Dinitrotoluene mixture	25321146	B2	2B	- -	- -	- -	1.90E-04 CO	- -	6.80E-01 IR	- -
71	2,4-Dinitrotoluene	121142	B2	2B	0.007 CA	- -	2.00E-03 IR	8.9E-005 CA	- -	3.10E-01 CA	5 NI

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Table 1. Dose-response assessment information, with sources, used for ranking.

HAP No.	Contaminant	CAS #	Weight of Evidence EPA	Weight of Evidence IARC	Chronic Inhalation Reference mg/m3	Inhalation Reference Dose mg/kg/d	Oral Reference Dose mg/kg/d	Inhalation Unit Risk m3/ug	Inhalation Potency Slope kg-d/mg	Oral Potency Slope kg-d/mg	Acute Inhalation Reference mg/m3
72	1,4-Dioxane	123911	B2	2B	3 CA	-	-	7.7E-006 CA	-	1.10E-02 IR	6 CA
73	1,2-Diphenylhydrazine	122667	B2	-	-	-	-	2.20E-04 IR	-	8.00E-01 IR	-
74	Epichlorohydrin	106898	B2	2A	0.001 IR	-	2.00E-03 HE	1.2E-006 IR	-	9.90E-03 IR	3 CA
75	1,2-Epoxybutane	106887	-	-	0.02 IR	-	-	-	-	-	-
76	Ethyl acrylate	140885	B2	2B	-	-	-	1.4E-005 CO	-	4.80E-02 HE	1400 NI
77	Ethylbenzene	100414	D	-	1 IR	-	1.00E-01 IR	-	-	-	350 NI
78	Ethyl carbamate (urethane)	51796	-	2B	-	-	-	2.90E-04 CA	-	1.00E+00 CA	-
79	Chloroethane (ethyl chloride)	75003	-	-	10 IR	-	-	-	-	-	1000 NI
80	1,2-Dibromoethane	106934	B2	2A	0.0002 HE	5.71E-05 HE	-	2.20E-04 IR	-	8.50E+01 IR	77 NI
81	1,2-Dichloroethane (EDC)	107062	B2	2B	0.81 AT	-	-	2.6E-005 IR	-	9.10E-02 IR	20 NI
82	Ethylene glycol	107211	-	-	0.4 CA	-	2.00E+00 IR	-	-	-	1.3 AT
83	Ethylene imine (aziridine)	151564	-	-	-	-	-	-	-	-	-
84	Ethylene oxide	75218	B1	1	0.005 CA	-	-	1.00E-04 HE	3.50E-01 HE	1.00E+00 HE	90 AI
85	Ethylene thiourea (ETU)	96457	B2	2B	0.003 CA	-	8E-005 IR	1.3E-005 CA	-	1.20E-01 HE	-
86	1,1-Dichloroethane	75343	C	-	0.5 HE	1.43E-01 HE	1.00E-01 HE	1.6E-006 CA	-	5.70E-03 CA	1200 NI
87	Formaldehyde	50000	B1	2A	0.0037 AT	-	2.00E-01 IR	1.3E-005 IR	-	2.10E-02 CA	0.3 CA
88	Heptachlor	76448	B2	2B	-	-	5.00E-04 IR	1.30E-03 IR	-	4.50E+00 IR	3.5 NI
89	Hexachlorobenzene	118741	B2	2B	0.003 CA	-	8.00E-04 IR	4.60E-04 IR	-	1.60E+00 IR	-
90	Hexachlorobutadiene	87683	C	3	0.09 CA	-	2.00E-04 HE	2.2E-005 IR	-	7.80E-02 IR	32 AI
91	Hexachlorocyclopentadiene	77474	D	-	0.00033 AT	2.00E-05 HE	7.00E-03 IR	-	-	-	-
92	Hexachloroethane	67721	C	3	0.08 CA	-	1.00E-03 IR	4E-006 IR	-	1.40E-02 IR	58 AT
93	Hexamethylene-1,6-diisocyanate	822060	-	-	1E-005 IR	-	-	-	-	-	-
94	Hexamethylphosphoramide	680319	-	-	-	-	-	-	-	-	-
95	n-Hexane	110543	-	-	0.2 IR	-	6.00E-02 HE	-	-	-	390 NI
96	Hydrazine, hydrazine sulfate	302012	B2	2B	0.0002 CA	-	-	4.90E-03 IR	-	3.00E+00 IR	6.5 NI
97	Hydrogen chloride	7647010	-	-	0.02 IR	-	-	-	-	-	2 CA
98	Hydrogen fluoride	7664393	-	-	0.03 CA	-	-	-	-	-	0.2 CA
99	Hydroquinone	123319	-	-	-	-	4.00E-02 HE	-	-	-	5 NI
100	Isophorone	78591	C	-	2 CA	-	2.00E-01 IR	2.7E-007 CO	-	9.50E-04 IR	-
101	alpha-Hexachlorocyclohexane (a-HCH)	319846	B2	-	0.02 CA	-	-	1.80E-03 IR	-	6.30E+00 IR	-
101	beta-Hexachlorocyclohexane (b-HCH)	319857	B2	-	0.002 CA	-	-	5.30E-04 IR	-	1.80E+00 IR	-
101	gamma-Hexachlorocyclohexane (g-HCH,Lindane)	58899	B2-C	-	0.0003 CA	-	3.00E-04 IR	3.10E-04 CA	-	1.30E+00 HE	5 NI
101	technical Hexachlorocyclohexane (HCH)	608731	B2	-	-	-	-	5.10E-04 IR	-	1.80E+00 IR	-
102	Maleic anhydride	108316	-	-	0.0002 CA	-	1.00E-01 IR	-	-	-	1 NI
103	Methanol	67561	-	-	10 CA	-	5.00E-01 IR	-	-	-	30 CA
104	Methoxychlor	72435	D	3	-	-	5.00E-03 IR	-	-	-	500 NI

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105	Bromomethane (methyl bromide)	74839	D	-	0.005 IR	-	1.40E-03 IR	-	-	-	4 CA
106	Chloromethane (methyl chloride)	74873	C	-	0.1 AT	-	-	1.8E-006 HE	6.30E-03 HE	1.30E-02 HE	830 AI
107	1,1,1-Trichloroethane	71556	D	-	1 CA	-	-	-	-	-	7 CA
108	Methyl ethyl ketone	78933	D	-	1 IR	-	6.00E-01 IR	-	-	-	70 CA
109	Methyl hydrazine	60344	B2	-	-	-	-	-	-	-	4.2 NA
110	Methyl iodide	74884	C	-	-	-	-	-	-	-	150 AI
111	Methyl isobutyl ketone	108101	-	-	0.08 HE	2.29E-02 HE	8.00E-02 HE	-	-	-	-
112	Methyl isocyanate	624839	-	-	0.001 CA	-	-	-	-	-	0.058 AI
113	Methyl methacrylate	80626	E	-	0.7 IR	-	1.40E+00 IR	-	-	-	410 NI
114	Methyl tertbutyl ether (MTBE)	1634044	-	-	3 IR	-	-	-	-	-	7.2 AT
115	4,4'-Methylene bis(2-chloroaniline)	101144	B2	2A	-	-	3.00E-03 AT	3.7E-005 HE	1.30E-01 HE	1.30E-01 HE	-
116	Methylene chloride	75092	B2	2B	3 HE	8.57E-01 HE	6.00E-02 IR	4.7E-007 IR	-	7.50E-03 IR	8 CA
117	4,4'-Methylenediphenyl diisocyanate	101688	D	-	0.0006 IR	-	-	-	-	-	0.2 AI
118	4,4'-Methylenedianiline	101779	-	2B	0.02 CA	-	-	4.60E-04 CA	-	1.60E+00 CA	-
119	Naphthalene	91203	C	-	0.003 IR	-	2.00E-02 IR	-	-	-	130 NI
120	Nitrobenzene	98953	D	2B	0.002 HE	5.71E-04 HE	5.00E-04 IR	-	-	-	100 NI
121	4-Nitrobiphenyl	92933	-	-	-	-	-	-	-	-	-
122	4-Nitrophenol	100027	-	-	-	-	-	-	-	-	-
123	2-Nitropropane	79469	B2	2B	0.02 IR	-	-	2.70E-03 HE	9.40E+00 HE	-	36 NI
124	N-Nitroso-N-methylurea	684935	-	-	-	-	-	-	-	-	-
125	N-Nitrosodimethylamine	62759	B2	2A	-	-	-	1.40E-02 IR	-	5.10E+01 IR	-
126	N-Nitrosomorpholine	59892	-	2B	-	-	-	1.90E-03 CA	-	6.70E+00 CA	-
127	Parathion	56382	C	3	-	-	6.00E-03 HE	-	-	-	1 NI
128	Pentachloronitrobenzene	82688	C	3	-	-	3.00E-03 IR	7.4E-005 CO	-	2.60E-01 HE	-
129	Pentachlorophenol	87865	B2	2B	0.1 CA	-	3.00E-02 IR	5.1E-006 CA	-	1.20E-01 IR	0.25 NI
130	Phenol	108952	D	3	0.6 CA	-	6.00E-01 IR	-	-	-	6 CA
131	p-Phenylenediamine	106503	-	-	-	-	1.90E-01 HE	-	-	-	-
132	Phosgene	75445	-	-	0.0003 CA	-	-	-	-	-	0.004 CA
133	Phosphine	7803512	-	-	0.0003 IR	-	3.00E-04 IR	-	-	-	0.35 NA
134	Phosphorus (white)	7723140	-	-	-	-	-	-	-	-	-
135	Phthalic anhydride	85449	-	-	0.12 HE	3.43E-02 HE	2.00E+00 IR	-	-	-	6 NI
136	Polychlorinated biphenyls (PCBs)	1336363	B2	2A	-	-	-	1.10E-04 IR	-	2.00E+00 IR	-
137	1,3-Propane sultone	1120714	-	-	-	-	-	6.90E-04 CA	-	2.40E+00 CA	-
138	beta-Propiolactone	57578	-	-	-	-	-	-	-	-	-
139	Propionaldehyde	123386	-	-	-	-	-	-	-	-	-
140	Baygon (propoxur)	114261	B2	-	-	-	4.00E-03 IR	-	-	-	-

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HAP No.	Contaminant	CAS #	Weight of Evidence EPA	Weight of Evidence IARC	Chronic Inhalation Reference mg/m3	Inhalation Reference Dose mg/kg/d	Oral Reference Dose mg/kg/d	Inhalation Unit Risk m3/ug	Inhalation Potency Slope kg-d/mg	Oral Potency Slope kg-d/mg	Acute Inhalation Reference mg/m3
141	1,2-Dichloropropane (propylene dichloride)	78875	B2	-	0.004 IR	-	9.00E-02 AT	1.9E-005 CO	-	6.80E-02 HE	180 NI
142	Propylene oxide	75569	B2	2B	0.03 IR	-	-	3.7E-006 IR	-	2.40E-01 IR	6 CA
143	1,2-Propylenimine (2-methyl aziridine)	75558	B2	-	-	-	-	-	-	-	-
144	Quinoline	91225	C	-	-	-	-	3.40E-03 CO	-	1.20E+01 HE	-
145	Quinone	106514	-	-	-	-	-	-	-	-	10 NI
146	Styrene	100425	-	2B	1 IR	-	2.00E-01 IR	-	-	-	20 CA
147	Styrene oxide	96093	-	2A	0.006 CA	-	-	-	-	-	-
148	2,3,7,8-TCDD (dioxin)	1746016	B2	-	-	-	1E-009 AT	3.30E+01 HE	1.50E+05 HE	1.50E+05 HE	-
149	1,1,2,2-Tetrachloroethane	79345	C	3	-	-	4.00E-02 AT	5.8E-005 IR	-	2.00E-01 IR	69 NI
150	Tetrachloroethylene (PCE)	127184	B2-C	2A	0.27 AT	-	1.00E-02 IR	5.9E-006 CA	-	5.10E-02 CA	10 CA
151	Titanium tetrachloride	7550450	-	-	0.0001 AT	-	-	-	-	-	5 AI
152	Toluene	108883	D	3	0.4 IR	-	2.00E-01 IR	-	-	-	40 CA
153	Toluene-2,4-diamine	95807	B2	-	-	-	-	1.10E-03 CA	-	3.20E+00 HE	-
154	2,4/2,6-Toluene diisocyanate mixture	26471625	-	2B	7E-005 IR	-	-	1.1E-005 CA	-	3.90E-02 CA	-
155	2-Methylaniline (o-toluidine)	95534	B2	2B	-	-	-	5.1E-005 CA	-	2.40E-01 HE	22 NI
156	Toxaphene	8001352	B2	2B	-	-	-	3.20E-04 IR	-	1.10E+00 IR	-
157	1,2,4-Trichlorobenzene	120821	D	-	0.2 HE	5.71e-02 HE	1.00E-02 IR	-	-	-	-
158	1,1,2-Trichloroethane	79005	C	3	0.4 CA	-	4.00E-03 IR	1.6E-005 IR	-	5.70E-02 IR	55 NI
159	Trichloroethylene (TCE)	79016	B2-C	2A	0.6 CA	-	-	2E-006 CA	-	1.50E-02 CA	540 AI
160	2,4,5-Trichlorophenol	95954	-	-	-	-	1.00E-01 IR	-	-	-	-
161	2,4,6-Trichlorophenol	88062	B2	-	-	-	-	3.1E-006 IR	-	1.10E-02 IR	-
162	Triethylamine	121448	-	-	0.007 IR	-	-	-	-	-	3 CA
163	Trifluralin	1582098	C	3	-	-	7.50E-03 IR	2.2E-006 CO	-	7.70E-03 IR	-
164	2,2,4-Trimethylpentane	540841	-	-	-	-	-	-	-	-	-
165	Vinyl acetate	108054	-	2B	0.2 IR	-	1.00E+00 HE	-	-	-	18 AI
166	Vinyl bromide	593602	B2	2A	0.003 IR	-	-	3.1E-005 HE	-	-	-
167	Vinyl chloride	75014	A	1	0.005 CA	-	2E-005 AT	8.6E-005 HE	3.00E-01 HE	1.90E+00 HE	200 CA
168	1,1-Dichloroethylene	75354	C	-	0.02 CA	-	9.00E-03 IR	5E-005 IR	-	6.00E-01 IR	-
169	Xylene (mixed)	1330207	D	-	0.43 AT	-	2.00E+00 IR	-	-	-	2 CA
170	o-Xylene	95476	-	-	-	-	2.00E+00 HE	-	-	-	390 NI
171	m-Xylene	108383	-	-	-	-	2.00E+00 HE	-	-	-	390 NI
172	p-Xylene	106423	-	-	-	-	-	-	-	-	390 NI
173	Antimony and compounds	7440360	-	-	0.0002 IR	-	4.00E-04 IR	-	-	-	5 NI
173	-Antimony pentafluoride	7783702	-	-	-	-	-	-	-	-	-
173	-Antimony pentoxide	1314609	-	-	-	-	5.00E-04 HE	-	-	-	-
173	-Antimony potassium tartrate	304610	-	-	-	-	9.00E-04 HE	-	-	-	-

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HAP			Weight of Evidence		Chronic Inhalation Reference	Inhalation Reference Dose	Oral Reference Dose	Inhalation Unit Risk	Inhalation Potency Slope	Oral Potency Slope	Acute Inhalation Reference
No.	Contaminant	CAS #	EPA	IARC	mg/m3	mg/kg/d	mg/kg/d	m3/ug	kg-d/mg	kg-d/mg	mg/m3
173	-Antimony tetroxide	1332816	-	-	- -	- -	4.00E-04 HE	- -	- -	- -	- -
173	-Antimony trioxide	1309644	B2	2B	0.0002 IR	- -	4.00E-04 HE	- -	- -	- -	- -
174	Arsenic and compounds	7440382	A	1	3E-005 CA	- -	3.00E-04 IR	4.30E-03 IR	- -	1.50E+00 IR	0.0004 CA
174	-Arsine	7784421	-	-	5E-005 IR	- -	- -	- -	- -	- -	0.5 NA
174	-Arsenic oxide	1327533	-	-	- -	- -	- -	- -	- -	- -	- -
174	-Arsenic pentoxide	1303282	-	-	- -	- -	- -	- -	- -	- -	- -
175	Beryllium and compounds	7440417	B1	1	2E-005 IR	- -	2.00E-03 IR	2.40E-03 IR	- -	- -	0.025 AI
176	Cadmium and compounds	7440439	B1	1	1E-005 CA	- -	5.00E-04 IR	1.80E-03 IR	- -	1.50E+01 CA	9 NI
176	-Cadmium oxide	1306190	-	-	- -	- -	- -	- -	- -	- -	- -
177	Chromium III and compounds	16065831	-	-	- -	- -	1.50E+00 IR	- -	- -	- -	2.5 NI
177	Chromium VI and compounds	18540299	A	1	0.0001 IR	- -	3.00E-03 IR	1.20E-02 IR	- -	4.20E-01 CA	1.5 NI
177	-Chromic chloride	10025737	-	-	- -	- -	- -	- -	- -	- -	- -
178	Cobalt and compounds	7440484	-	-	- -	- -	- -	- -	- -	- -	2 NI
178	-Cobalt carbonyl	10210681	-	-	- -	- -	- -	- -	- -	- -	- -
179	Coke Oven Emissions	8007452	A	-	- -	- -	- -	6.20E-04 IR	- -	- -	- -
180	Cyanide compounds	57125	D	-	- -	- -	2.00E-02 IR	- -	- -	- -	2.5 NI
180	-Barium cyanide	542621	-	-	- -	- -	- -	- -	- -	- -	- -
180	-Calcium cyanide	592018	-	-	- -	- -	4.00E-02 IR	- -	- -	- -	- -
180	-Chlorine cyanide	506774	-	-	- -	- -	5.00E-02 IR	- -	- -	- -	1 AI
180	-Copper cyanide	544923	-	-	- -	- -	5.00E-03 IR	- -	- -	- -	- -
180	-Cyanazine	21725462	C	-	- -	- -	2.00E-03 HE	2.40E-04 CO	- -	8.40E-01 HE	- -
180	-Cyanogen	460195	-	-	- -	- -	4.00E-02 IR	- -	- -	- -	- -
180	-Cyanogen bromide	506683	-	-	- -	- -	9.00E-02 IR	- -	- -	- -	- -
180	-Cyanogen chloride	506774	-	-	- -	- -	5.00E-02 IR	- -	- -	- -	1 AI
180	-Free cyanide	57125	D	-	- -	- -	2.00E-02 IR	- -	- -	- -	2.5 NI
180	-Hydrogen cyanide	74908	-	-	0.003 IR	- -	2.00E-02 IR	- -	- -	- -	0.3 CA
180	-Potassium cyanide	151508	-	-	- -	- -	5.00E-02 IR	- -	- -	- -	- -
180	-Potassium silver cyanide	506616	-	-	- -	- -	2.00E-01 IR	- -	- -	- -	- -
180	-Silver cyanide	506649	-	-	- -	- -	1.00E-01 IR	- -	- -	- -	- -
180	-Sodium cyanide	143339	-	-	- -	- -	4.00E-02 IR	- -	- -	- -	- -
180	-Thiocyanate	THIOCYA	-	-	- -	- -	- -	- -	- -	- -	- -
180	-Zinc cyanide	557211	-	-	- -	- -	5.00E-02 IR	- -	- -	- -	- -
181	Glycol ethers		-	-	0.02 --	5.71E-03 --	1.00E-03 --	- -	- -	- -	- -
181	-Diethylene glycol, monobutyl ether	112345	-	-	0.02 HE	5.71E-03 HE	- -	- -	- -	- -	- -
181	-Diethylene glycol, monoethyl ether	111900	-	-	- -	- -	2.00E+00 HE	- -	- -	- -	- -
181	-2-Ethoxyethanol (ethylene glycol ethyl e	110805	-	-	0.2 IR	- -	4.00E-01 HE	- -	- -	- -	0.9 CA

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Table 1. Dose-response assessment information, with sources, used for ranking.

HAP No.	Contaminant	CAS #	Weight of Evidence EPA	Weight of Evidence IARC	Chronic Inhalation Reference mg/m3	Inhalation Reference Dose mg/kg/d	Oral Reference Dose mg/kg/d	Inhalation Unit Risk m3/ug	Inhalation Potency Slope kg-d/mg	Oral Potency Slope kg-d/mg	Acute Inhalation Reference mg/m3
181	-Ethylene glycol monobutyl ether	111762	-	-	0.02 HE	5.71E-03 HE	- -	- -	- -	- -	10 CA
181	-2-Methoxyethanol acetate	110496	-	-	0.09 CA	- -	2.00E-03 HE	- -	- -	- -	- -
181	-2-Methoxyethanol	109864	-	-	0.02 IR	- -	1.00E-03 HE	- -	- -	- -	0.02 CA
182	Lead and lead compounds	7439921	B2	2B	0.0015 --	- -	- -	1.2E-005 CA	- -	8.50E-03 CA	10 NI
182	-Tetramethyl lead	75741	-	-	- -	- -	- -	- -	- -	- -	4 NI
182	-Tetraethyl lead	78002	-	-	- -	- -	1E-007 IR	- -	- -	- -	4 NI
183	Manganese and compounds	7439965	D	-	5E-005 IR	- -	2.30E-02 IR	- -	- -	- -	50 NI
183	-Methylcyclopentadienyl manganese	12108133	-	-	- -	- -	- -	- -	- -	- -	- -
184	Mercury and compounds	7439976	D	-	0.0003 IR	- -	1.00E-04 IR	- -	- -	- -	0.002 CA
184	-Mercury (elemental)	7439976	D	-	0.0003 IR	- -	1.00E-04 IR	- -	- -	- -	0.002 CA
184	-Mercuric chloride	7487947	C	-	- -	- -	3.00E-04 IR	- -	- -	- -	- -
184	-Mercury (methyl)	22967926	C	-	- -	- -	1.00E-04 IR	- -	- -	- -	0.2 NI
186	Nickel and compounds	7440020	A	2B	0.0002 AT	- -	2.00E-02 IR	1.20E-04 --	- -	9.10E-01 CA	0.01 CA
186	-Nickel refinery dust	NI_DUST	A	-	- -	- -	- -	2.40E-04 IR	- -	- -	- -
186	-Nickel subsulfide	12035722	A	-	- -	- -	- -	4.80E-04 IR	- -	- -	- -
187	Polycyclic Organic Matter	POM	-	-	- -	- -	- -	- -	- -	- -	- -
187	Carcinogenic PAHs: 7-PAH					- -		3.30E-04 --	- -	2.43E+00 --	
187	-Acenaphthene	83329	-	-	- -	- -	6.00E-02 IR	- -	- -	- -	- -
187	-Anthracene	120127	D	3	- -	- -	3.00E-01 IR	- -	- -	- -	- -
187	-Benz[a]anthracene	56553	B2	2A	- -	- -	- -	1.10E-04 CA	3.10E-01 EP	1.20E+00 CA	- -
187	-Benzo[b]fluoranthene	205992	B2	2B	- -	- -	- -	1.10E-04 CA	3.10E-01 EP	1.20E+00 CA	- -
187	-Benzo[k]fluoranthene	207089	B2	2B	- -	- -	- -	1.10E-04 CA	3.10E-02 EP	1.20E+00 CA	- -
187	-Benzo[a]pyrene	50328	B2	2A	- -	- -	- -	1.10E-03 CA	3.10E+00 EP	7.30E+00 IR	- -
187	-Carbazole	86748	B2	-	- -	- -	- -	5.7E-006 CO	- -	2.00E-02 HE	- -
187	-Chrysene	218019	B2	-	- -	- -	- -	1.1E-005 CA	- -	1.20E-01 CA	- -
187	-Dibenz[a,h]acridine	226368	-	-	- -	- -	- -	1.10E-04 CA	- -	1.20E+00 CA	- -
187	-Dibenz[a,j]acridine	224420	-	-	- -	- -	- -	1.10E-04 CA	- -	1.20E+00 CA	- -
187	-Dibenz[a,h]anthracene	53703	B2	2A	- -	- -	- -	3.90E-04 CA	3.10E+00 EP	4.10E+00 CA	- -
187	-7H-Dibenzo[c,g]carbazole	194592	-	-	- -	- -	- -	1.10E-03 CA	- -	1.20E+01 CA	- -
187	-Dibenzo[a,e]pyrene	192654				- -		1.10E-03 CA	- -	1.20E+01 C	
187	-Dibenzo[a,i]pyrene	189559	-	-	- -	- -	- -	1.10E-02 CA	- -	1.20E+02 CA	- -
187	-Dibenzo[a,l]pyrene	191300	-	-	- -	- -	- -	1.10E-02 CA	- -	1.20E+02 CA	- -
187	-7,12-Dimethylbenz[a]anthracene	57976	B2	-	- -	- -	- -	2.40E-02 CA	- -	2.50E+02 CA	- -
187	-1,6-Dinitropyrene	42397648	-	-	- -	- -	- -	1.10E-02 CA	- -	1.20E+02 CA	- -
187	-1,8-Dinitropyrene	42397659	-	-	- -	- -	- -	1.10E-03 CA	- -	1.20E+01 CA	- -
187	-Fluoranthene	206440	D	-	- -	- -	4.00E-02 IR	- -	- -	- -	- -

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Table 1. Dose-response assessment information, with sources, used for ranking.

HAP No.	Contaminant	CAS #	Weight of Evidence EPA	Weight of Evidence IARC	Chronic Inhalation Reference mg/m3	Inhalation Reference Dose mg/kg/d	Oral Reference Dose mg/kg/d	Inhalation Unit Risk m3/ug	Inhalation Potency Slope kg-d/mg	Oral Potency Slope kg-d/mg	Acute Inhalation Reference mg/m3
187	-Fluorene	86737	D	-	- -	- -	4.00E-02 IR	- -	- -	- -	- -
187	-Hexachlorodibenzo-p-dioxin mixture	19408743	B2	-	- -	- -	- -	1.30E+00 IR	- -	6.20E+03 IR	- -
187	-Indeno[1,2,3-cd]pyrene	193395	B2	2B	- -	- -	- -	1.10E-04 CA	3.10E-01 EP	1.20E+00 CA	- -
187	-3-Methylcholanthrene	56495	-	-	- -	- -	- -	2.10E-03 CA	- -	2.20E+01 CA	- -
187	-5-Methylchrysene	3697243	-	-	- -	- -	- -	1.10E-03 CA	- -	1.20E+01 CA	- -
187	-2-Methylnaphthalene	91576	-	-	- -	- -	- -	- -	- -	- -	- -
187	-5-Nitroacenaphthene	602879	-	-	- -	- -	- -	1.1E-005 CA	- -	1.30E-01 CA	- -
187	-6-Nitrochrysene	2043937	-	-	- -	- -	- -	1.10E-02 CA	- -	1.20E+02 CA	- -
187	-2-Nitrofluorene	607578	-	-	- -	- -	- -	1.1E-005 CA	- -	1.30E-01 CA	- -
187	-2-Nitrofluorene	607578	-	-	- -	- -	- -	1.1E-005 CA	- -	1.30E-01 CA	- -
187	-1-Nitropyrene	5522430	-	-	- -	- -	- -	1.10E-04 CA	- -	1.20E+00 CA	- -
187	-4-Nitropyrene	57835924	-	-	- -	- -	- -	1.10E-04 CA	- -	1.20E+00 CA	- -
187	-Pyrene	129000	D	-	- -	- -	3.00E-02 IR	- -	- -	- -	- -
189	Selenium	7782492	D	-	- -	- -	5.00E-03 IR	- -	- -	- -	- -
189	-Hydrogen selenide	2148909	-	-	- -	- -	- -	- -	- -	- -	0.33 NI
189	-Selenious Acid	7783008	D	-	- -	- -	5.00E-03 IR	- -	- -	- -	- -
189	-Sodium selenate	13410010	D	-	- -	- -	- -	- -	- -	- -	- -
189	-Sodium selenite	10102188	D	-	- -	- -	- -	- -	- -	- -	- -

Key to Letter Codes:

Source of Dose-Response Assessment

IR=EPA Integrated Risk Information System (IRIS)
AT=ATSDR Minimum Risk Level (MRL)
NA=NAC Acute Exposure Guideline Level (1-hr Level II)
HE=EPA Health Effects Assessment Summary Tables (HEAST)
CA=California EPA
AI=AIHA Emergency Removal Program Guidelines
NI=10% of NIOSH Immediately Dangerous to Life or Health
CO=Converted from oral benchmark

Table 2. Calculated risk-based concentrations (for inhalation) and risk-based doses (for oral exposure) used in ranking. Case 1: exposure at 1e-6 risk or HQ=1, whichever is less. Case 2: exposure at 1e-4 risk or HQ=1, whichever is less.

HAP			Risk-Based Concentrations for Inhalation						Risk-Based Doses for Ingestion				
			Cancer		Non-Cancer	Acute	Chronic RBCs Used for Indexing		Cancer		Non-Cancer	Chronic RBDs Used for Indexing	
			1.0E-06	1.0E-04					1.0E-06	1.0E-04			
No.	Contaminant	CAS #	ug/m3		ug/m3	ug/m3	Case 1	Case 2	mg/kg/d		mg/kg/d	Case 1	Case 2
1	Acetaldehyde	75070	4.5E-01	4.5E+01	9.0E+00	1.8E+04	4.5E-01	9.0E+00	1.0E-04	1.0E-02		1.0E-04	1.0E-02
2	Acetamide	60355	5.0E-02	5.0E+00			5.0E-02	5.0E+00	1.4E-05	1.4E-03		1.4E-05	1.4E-03
3	Acetonitrile	75058			5.0E+01	8.4E+04	5.0E+01	5.0E+01			6.0E-03	6.0E-03	6.0E-03
4	Acetophenone	98862									1.0E-01	1.0E-01	1.0E-01
5	2-Acetylaminofluorene	53963											
6	Acrolein	107028			2.0E-02	4.0E-01	2.0E-02	2.0E-02			5.0E-04	5.0E-04	5.0E-04
7	Acrylamide	79061	7.7E-04	7.7E-02	7.0E-01	6.0E+03	7.7E-04	7.7E-02	2.2E-07	2.2E-05	2.0E-04	2.2E-07	2.2E-05
8	Acrylic acid	79107			1.0E+00	6.0E+03	1.0E+00	1.0E+00			5.0E-01	5.0E-01	5.0E-01
9	Acrylonitrile	107131	1.5E-02	1.5E+00	2.0E+00	2.2E+04	1.5E-02	1.5E+00	1.9E-06	1.9E-04	4.0E-02	1.9E-06	1.9E-04
10	Allyl chloride	107051	1.7E-01	1.7E+01	1.0E+00	9.4E+03	1.7E-01	1.0E+00	4.8E-05	4.8E-03		4.8E-05	4.8E-03
11	4-Aminobiphenyl	92671											
12	Aniline	62533	6.3E-01	6.3E+01	1.0E+00	3.0E+04	6.3E-01	1.0E+00	1.8E-04	1.8E-02		1.8E-04	1.8E-02
13	o-Anisidine	90040				5.0E+03							
14	Asbestos*	1332214											
15	Benzene	71432	1.3E-01	1.3E+01	6.0E+01	8.0E+02	1.3E-01	1.3E+01	3.4E-05	3.4E-03		3.4E-05	3.4E-03
16	Benzidine	92875	1.5E-05	1.5E-03	1.0E+01		1.5E-05	1.5E-03	4.3E-09	4.3E-07	3.0E-03	4.3E-09	4.3E-07
17	Benzotrichloride	98077	2.7E-04	2.7E-02			2.7E-04	2.7E-02	7.7E-08	7.7E-06		7.7E-08	7.7E-06
18	Benzyl chloride	100447	2.0E-02	2.0E+00		5.0E+02	2.0E-02	2.0E+00	5.9E-06	5.9E-04		5.9E-06	5.9E-04
19	1,1-Biphenyl	92524									5.0E-02	5.0E-02	5.0E-02
20	Bis(2-ethylhexyl)phthalate (DEHP)	117817	4.2E-01	4.2E+01	1.0E+01		4.2E-01	1.0E+01	7.1E-05	7.1E-03	2.0E-02	7.1E-05	7.1E-03
21	Bis(chloromethyl)ether	542881	1.6E-05	1.6E-03			1.6E-05	1.6E-03	4.5E-09	4.5E-07		4.5E-09	4.5E-07
22	Bromoform (tribromomethane)	75252	9.1E-01	9.1E+01		8.8E+05	9.1E-01	9.1E+01	1.3E-04	1.3E-02	2.0E-02	1.3E-04	1.3E-02
23	1,3-Butadiene	106990	3.6E-03	3.6E-01	8.0E+00	2.2E+04	3.6E-03	3.6E-01	2.9E-07	2.9E-05		2.9E-07	2.9E-05
24	Calcium cyanamide	156627											
25	Caprolactam	105602									5.0E-01	5.0E-01	5.0E-01
26	Captan	133062	1.0E+00	1.0E+02			1.0E+00	1.0E+02	2.9E-04	2.9E-02	1.3E-01	2.9E-04	2.9E-02
27	Carbaryl	63252				1.0E+04					1.0E-01	1.0E-01	1.0E-01
28	Carbon disulfide	75150			7.0E+02	2.0E+04	7.0E+02	7.0E+02			1.0E-01	1.0E-01	1.0E-01
29	Carbon tetrachloride	56235	6.7E-02	6.7E+00	4.0E+01	5.0E+03	6.7E-02	6.7E+00	7.7E-06	7.7E-04	7.0E-04	7.7E-06	7.0E-04
30	Carbonyl sulfide	463581											
31	Catechol	120809											
32	Chloramben	133904									1.5E-02	1.5E-02	1.5E-02
33	Chlordane	57749	1.0E-02	1.0E+00	7.0E-01	1.0E+04	1.0E-02	7.0E-01	2.9E-06	2.9E-04	5.0E-04	2.9E-06	2.9E-04
34	Chlorine	7782505			2.0E+01	2.9E+03	2.0E+01	2.0E+01			1.0E-01	1.0E-01	1.0E-01
35	Chloroacetic acid	79118									2.0E-03	2.0E-03	2.0E-03
36	2-Chloroacetophenone	532274			3.0E-02		3.0E-02	3.0E-02					
37	Chlorobenzene	108907			2.0E+01	4.6E+05	2.0E+01	2.0E+01			2.0E-02	2.0E-02	2.0E-02
38	Chlorobenzilate	510156	1.3E-02	1.3E+00			1.3E-02	1.3E+00	3.7E-06	3.7E-04	2.0E-02	3.7E-06	3.7E-04
39	Chloroform	67663	4.3E-02	4.3E+00	9.8E+01	4.0E+02	4.3E-02	4.3E+00	1.6E-04	1.6E-02	1.0E-02	1.6E-04	1.0E-02
40	Chloromethyl methyl ether	107302											
41	2-Chloro-1,3-butadiene (chloroprene)	126998			7.0E+00	1.1E+05	7.0E+00	7.0E+00			2.0E-02	2.0E-02	2.0E-02
42	Cresols/cresylic acid (isomers and mixture)	1319773			4.0E+00	1.1E+05	4.0E+00	4.0E+00					

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Table 2. Calculated risk-based concentrations (for inhalation) and risk-based doses (for oral exposure) used in ranking. Case 1: exposure at 1e-6 risk or HQ=1, whichever is less. Case 2: exposure at 1e-4 risk or HQ=1, whichever is less.

HAP			Risk-Based Concentrations for Inhalation						Risk-Based Doses for Ingestion				
			Cancer		Non-Cancer	Acute	Chronic RBCs Used for Indexing		Cancer		Non-Cancer	Chronic RBDs Used for Indexing	
			1.0E-06	1.0E-04					1.0E-06	1.0E-04			
No.	Contaminant	CAS #	ug/m3		ug/m3	ug/m3	Case 1	Case 2	mg/kg/d		mg/kg/d	Case 1	Case 2
43	2-Methylphenol (o-cresol)	95487		.	.	1.1E+05 •				.	5.0E-02 [1]	5.0E-02	5.0E-02
44	3-Methylphenol (m-cresol)	108394		.	.	1.1E+05 •				.	5.0E-02 [1]	5.0E-02	5.0E-02
45	4-Methylphenol (p-cresol)	106445		.	.	1.1E+05 •				.	5.0E-03 [3]	5.0E-03	5.0E-03
46	Cumene	98828		.	4.0E+02 [1]	4.4E+05 •	4.0E+02	4.0E+02		.	1.0E-01 [1]	1.0E-01	1.0E-01
47	2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757		.	.	1.0E+04 •				.	1.0E-02 [1]	1.0E-02	1.0E-02
48	DDE	72559	1.0E-02	1.0E+00 ••	.	.	1.0E-02	1.0E+00	2.9E-06	2.9E-04 [1]	.	2.9E-06	2.9E-04
49	Diazomethane	334883		.	.	.				.	.		
50	Dibenzofuran	132649		.	.	.				.	.		
51	1,2-Dibromo-3-chloropropane	96128	1.4E+00	1.4E+02 [3]	2.0E-01 [1]	.	2.0E-01	2.0E-01	7.1E-07	7.1E-05 [3]	.	7.1E-07	7.1E-05
52	Dibutyl phthalate	84742		.	.	4.0E+05 •				.	1.0E-01 [1]	1.0E-01	1.0E-01
53	1,4-Dichlorobenzene	106467		.	8.0E+02 [1]	9.0E+04 •	8.0E+02	8.0E+02	4.2E-05	4.2E-03 [3]	.	4.2E-05	4.2E-03
54	3,3'-Dichlorobenzidine	91941	2.9E-03	2.9E-01 [4]	.	.	2.9E-03	2.9E-01	2.2E-06	2.2E-04 [1]	.	2.2E-06	2.2E-04
55	Bis(2-chloroethyl)ether	111444	3.0E-03	3.0E-01 [1]	.	5.8E+04 •	3.0E-03	3.0E-01	9.1E-07	9.1E-05 [1]	.	9.1E-07	9.1E-05
56	1,3-Dichloropropene	542756	2.7E-02	2.7E+00 [3]	2.0E+01 [1]	.	2.7E-02	2.7E+00	5.6E-06	5.6E-04 [3]	3.0E-04 [1]	5.6E-06	3.0E-04
57	Dichlorvos	62737	1.2E-02	1.2E+00 ••	5.0E-01 [1]	1.0E+04 •	1.2E-02	5.0E-01	3.4E-06	3.4E-04 [1]	5.0E-04 [1]	3.4E-06	3.4E-04
58	Diethanolamine	111422		.	2.0E+01 [4]	.	2.0E+01	2.0E+01		.	.		
59	N-N-Dimethylaniline	121697		.	.	5.0E+04 •				.	2.0E-03 [1]	2.0E-03	2.0E-03
60	Diethyl sulfate	64675		.	.	.				.	.		
61	3,3'-Dimethoxybenzidine	119904	2.5E-01	2.5E+01 ••	.	.	2.5E-01	2.5E+01	7.1E-05	7.1E-03 [3]	.	7.1E-05	7.1E-03
62	p-Dimethylaminoazobenzene	60117	7.7E-04	7.7E-02 [4]	.	.	7.7E-04	7.7E-02	2.2E-07	2.2E-05 [4]	.	2.2E-07	2.2E-05
63	3,3'-Dimethylbenzidine	119937	3.8E-04	3.8E-02 ••	.	.	3.8E-04	3.8E-02	1.1E-07	1.1E-05 [3]	.	1.1E-07	1.1E-05
64	Dimethyl carbamoyl chloride	79447		.	.	.				.	.		
65	N,N-Dimethylformamide	68122		:	3.0E+01 [1]	6.0E+03 [4]	3.0E+01	3.0E+01		.	1.0E-01 [3]	1.0E-01	1.0E-01
66	1,1-Dimethylhydrazine	57147		.	.	7.4E+03 [2]				.	.		
67	Dimethyl phthalate	131113		.	.	2.0E+05 •				.	.		
68	Dimethyl sulfate	77781		.	.	3.6E+03 •				.	.		
69	4,6-Dinitro-2-methylphenol	534521		.	.	5.0E+02 •				.	.		
70	2,4-Dinitrophenol	51285		.	.	.				.	2.0E-03 [1]	2.0E-03	2.0E-03
71	Dinitrotoluene mixture	25321146	5.3E-03	5.3E-01 ••	.	.	5.3E-03	5.3E-01	1.5E-06	1.5E-04 [1]	.	1.5E-06	1.5E-04
71	2,4-Dinitrotoluene	121142	1.1E-02	1.1E+00 [4]	7.0E+00 [4]	5.0E+03 •	1.1E-02	1.1E+00	3.2E-06	3.2E-04 [4]	2.0E-03 [1]	3.2E-06	3.2E-04
72	1,4-Dioxane	123911	1.3E-01	1.3E+01 [4]	3.0E+03 [4]	6.0E+03 [3]	1.3E-01	1.3E+01	9.1E-05	9.1E-03 [1]	.	9.1E-05	9.1E-03
73	1,2-Diphenylhydrazine	122667	4.5E-03	4.5E-01 [1]	.	.	4.5E-03	4.5E-01	1.3E-06	1.3E-04 [1]	.	1.3E-06	1.3E-04
74	Epichlorohydrin	106898	8.3E-01	8.3E+01 [1]	1.0E+00 [1]	3.0E+03 [3]	8.3E-01	1.0E+00	1.0E-04	1.0E-02 [1]	2.0E-03 [3]	1.0E-04	2.0E-03
75	1,2-Epoxybutane	106887		.	2.0E+01 [1]	.	2.0E+01	2.0E+01		.	.		
76	Ethyl acrylate	140885	7.1E-02	7.1E+00 ••	.	1.4E+06 •	7.1E-02	7.1E+00	2.1E-05	2.1E-03 [3]	.	2.1E-05	2.1E-03
77	Ethylbenzene	100414		.	1.0E+03 [1]	3.5E+05 •	1.0E+03	1.0E+03		.	1.0E-01 [1]	1.0E-01	1.0E-01
78	Ethyl carbamate (urethane)	51796	3.4E-03	3.4E-01 [4]	.	.	3.4E-03	3.4E-01	1.0E-06	1.0E-04 [4]	.	1.0E-06	1.0E-04
79	Chloroethane (ethyl chloride)	75003		.	1.0E+04 [1]	1.0E+06 •	1.0E+04	1.0E+04		.	.		
80	1,2-Dibromoethane	106934	4.5E-03	4.5E-01 [1]	2.0E-01 [3]	7.7E+04 •	4.5E-03	2.0E-01	1.2E-08	1.2E-06 [1]	.	1.2E-08	1.2E-06
81	1,2-Dichloroethane (EDC)	107062	3.8E-02	3.8E+00 [1]	8.1E+02 [2]	2.0E+04 •	3.8E-02	3.8E+00	1.1E-05	1.1E-03 [1]	.	1.1E-05	1.1E-03
82	Ethylene glycol	107211		.	4.0E+02 [4]	1.3E+03 [7]	4.0E+02	4.0E+02		.	2.0E+00 [1]	2.0E+00	2.0E+00
83	Ethylene imine (aziridine)	151564		.	.	.				.	.		

Table 2. Calculated risk-based concentrations (for inhalation) and risk-based doses (for oral exposure) used in ranking. Case 1: exposure at 1e-6 risk or HQ=1, whichever is less. Case 2: exposure at 1e-4 risk or HQ=1, whichever is less.

HAP			Risk-Based Concentrations for Inhalation						Risk-Based Doses for Ingestion				
			Cancer		Non-Cancer	Acute	Chronic RBCs Used for Indexing		Cancer		Non-Cancer	Chronic RBDs Used for Indexing	
			1.0E-06	1.0E-04					1.0E-06	1.0E-04			
No.	Contaminant	CAS #	ug/m3		ug/m3	ug/m3	Case 1	Case 2	mg/kg/d		mg/kg/d	Case 1	Case 2
84	Ethylene oxide	75218	1.0E-02	1.0E+00	5.0E+00	9.0E+04	1.0E-02	1.0E+00	1.0E-06	1.0E-04	.	1.0E-06	1.0E-04
85	Ethylene thiourea (ETU)	96457	7.7E-02	7.7E+00	3.0E+00	.	7.7E-02	3.0E+00	8.3E-06	8.3E-04	8E-005	8.3E-06	8.3E-04
86	1,1-Dichloroethane	75343	6.3E-01	6.3E+01	5.0E+02	1.2E+06	6.3E-01	6.3E+01	1.8E-04	1.8E-02	1.0E-01	1.8E-04	1.8E-02
87	Formaldehyde	50000	7.7E-02	7.7E+00	3.7E+00	3.0E+02	7.7E-02	3.7E+00	4.8E-05	4.8E-03	2.0E-01	4.8E-05	4.8E-03
88	Heptachlor	76448	7.7E-04	7.7E-02	.	3.5E+03	7.7E-04	7.7E-02	2.2E-07	2.2E-05	5.0E-04	2.2E-07	2.2E-05
89	Hexachlorobenzene	118741	2.2E-03	2.2E-01	3.0E+00	.	2.2E-03	2.2E-01	6.3E-07	6.3E-05	8.0E-04	6.3E-07	6.3E-05
90	Hexachlorobutadiene	87683	4.5E-02	4.5E+00	9.0E+01	3.2E+04	4.5E-02	4.5E+00	1.3E-05	1.3E-03	2.0E-04	1.3E-05	2.0E-04
91	Hexachlorocyclopentadiene	77474		.	3.3E-01	.	3.3E-01	3.3E-01		.	7.0E-03	7.0E-03	7.0E-03
92	Hexachloroethane	67721	2.5E-01	2.5E+01	8.0E+01	5.8E+04	2.5E-01	2.5E+01	7.1E-05	7.1E-03	1.0E-03	7.1E-05	1.0E-03
93	Hexamethylene-1,6-diisocyanate	822060		.	1.0E-02	.	1.0E-02	1.0E-02		.	.		
94	Hexamethylphosphoramide	680319		.	.	.				.	.		
95	n-Hexane	110543		.	2.0E+02	3.9E+05	2.0E+02	2.0E+02		.	6.0E-02	6.0E-02	6.0E-02
96	Hydrazine, hydrazine sulfate	302012	2.0E-04	2.0E-02	2.0E-01	6.5E+03	2.0E-04	2.0E-02	3.3E-07	3.3E-05	.	3.3E-07	3.3E-05
97	Hydrogen chloride	7647010		.	2.0E+01	2.0E+03	2.0E+01	2.0E+01		.	.		
98	Hydrogen fluoride	7664393		.	3.0E+01	2.0E+02	3.0E+01	3.0E+01		.	.		
99	Hydroquinone	123319		.	.	5.0E+03				.	4.0E-02	4.0E-02	4.0E-02
100	Isophorone	78591	3.7E+00	3.7E+02	2.0E+03	.	3.7E+00	3.7E+02	1.1E-03	1.1E-01	2.0E-01	1.1E-03	1.1E-01
101	alpha-Hexachlorocyclohexane (a-HCH)	319846	5.6E-04	5.6E-02	2.0E+01	.	5.6E-04	5.6E-02	1.6E-07	1.6E-05	.	1.6E-07	1.6E-05
101	beta-Hexachlorocyclohexane (b-HCH)	319857	1.9E-03	1.9E-01	2.0E+00	.	1.9E-03	1.9E-01	5.6E-07	5.6E-05	.	5.6E-07	5.6E-05
101	gamma-Hexachlorocyclohexane (g-HCH,Lindan	58899	3.2E-03	3.2E-01	3.0E-01	5.0E+03	3.2E-03	3.0E-01	7.7E-07	7.7E-05	3.0E-04	7.7E-07	7.7E-05
101	technical Hexachlorocyclohexane (HCH)	608731	2.0E-03	2.0E-01	.	.	2.0E-03	2.0E-01	5.6E-07	5.6E-05	.	5.6E-07	5.6E-05
102	Maleic anhydride	108316		.	2.0E-01	1.0E+03	2.0E-01	2.0E-01		.	1.0E-01	1.0E-01	1.0E-01
103	Methanol	67561		.	1.0E+04	3.0E+04	1.0E+04	1.0E+04		.	5.0E-01	5.0E-01	5.0E-01
104	Methoxychlor	72435		.	.	5.0E+05				.	5.0E-03	5.0E-03	5.0E-03
105	Bromomethane (methyl bromide)	74839		.	5.0E+00	4.0E+03	5.0E+00	5.0E+00		.	1.4E-03	1.4E-03	1.4E-03
106	Chloromethane (methyl chloride)	74873	5.6E-01	5.6E+01	1.0E+02	8.3E+05	5.6E-01	5.6E+01	7.7E-05	7.7E-03	.	7.7E-05	7.7E-03
107	1,1,1-Trichloroethane	71556		.	1.0E+03	7.0E+03	1.0E+03	1.0E+03		.	.		
108	Methyl ethyl ketone	78933		.	1.0E+03	7.0E+04	1.0E+03	1.0E+03		.	6.0E-01	6.0E-01	6.0E-01
109	Methyl hydrazine	60344		.	.	4.2E+03				.	.		
110	Methyl iodide	74884		.	.	1.5E+05				.	.		
111	Methyl isobutyl ketone	108101		.	8.0E+01	.	8.0E+01	8.0E+01		.	8.0E-02	8.0E-02	8.0E-02
112	Methyl isocyanate	624839		.	1.0E+00	5.8E+01	1.0E+00	1.0E+00		.	.		
113	Methyl methacrylate	80626		.	7.0E+02	4.1E+05	7.0E+02	7.0E+02		.	1.4E+00	1.4E+00	1.4E+00
114	Methyl tertbutyl ether (MTBE)	1634044		.	3.0E+03	7.2E+03	3.0E+03	3.0E+03		.	.		
115	4,4'-Methylene bis(2-chloroaniline)	101144	2.7E-02	2.7E+00	.	.	2.7E-02	2.7E+00	7.7E-06	7.7E-04	3.0E-03	7.7E-06	7.7E-04
116	Methylene chloride	75092	2.1E+00	2.1E+02	3.0E+03	8.0E+03	2.1E+00	2.1E+02	1.3E-04	1.3E-02	6.0E-02	1.3E-04	1.3E-02
117	4,4'-Methylenediphenyl diisocyanate	101688		.	6.0E-01	2.0E+02	6.0E-01	6.0E-01		.	.		
118	4,4'-Methylenedianiline	101779	2.2E-03	2.2E-01	2.0E+01	.	2.2E-03	2.2E-01	6.3E-07	6.3E-05	.	6.3E-07	6.3E-05
119	Naphthalene	91203		.	3.0E+00	1.3E+05	3.0E+00	3.0E+00		.	2.0E-02	2.0E-02	2.0E-02
120	Nitrobenzene	98953		.	2.0E+00	1.0E+05	2.0E+00	2.0E+00		.	5.0E-04	5.0E-04	5.0E-04
121	4-Nitrobiphenyl	92933		.	.	.				.	.		
122	4-Nitrophenol	100027		.	.	.				.	.		

Table 2. Calculated risk-based concentrations (for inhalation) and risk-based doses (for oral exposure) used in ranking. Case 1: exposure at 1e-6 risk or HQ=1, whichever is less. Case 2: exposure at 1e-4 risk or HQ=1, whichever is less.

HAP No.	Contaminant	CAS #	Inhalation Cancer 1.0E-06 (ug/m3)	Inhalation Cancer 1.0E-04 (ug/m3)	Inhalation Non-Cancer (ug/m3)	Inhalation Acute (ug/m3)	Chronic RBCs Used for Indexing Case 1	Chronic RBCs Used for Indexing Case 2	Ingestion Cancer 1.0E-06 (mg/kg/d)	Ingestion Cancer 1.0E-04 (mg/kg/d)	Ingestion Non-Cancer (mg/kg/d)	Chronic RBDs Used for Indexing Case 1	Chronic RBDs Used for Indexing Case 2
123	2-Nitropropane	79469	3.7E-04	3.7E-02	2.0E+01	3.6E+04	3.7E-04	3.7E-02					
124	N-Nitroso-N-methylurea	684935											
125	N-Nitrosodimethylamine	62759	7.1E-05	7.1E-03			7.1E-05	7.1E-03	2.0E-08	2.0E-06		2.0E-08	2.0E-06
126	N-Nitrosomorpholine	59892	5.3E-04	5.3E-02			5.3E-04	5.3E-02	1.5E-07	1.5E-05		1.5E-07	1.5E-05
127	Parathion	56382				1.0E+03					6.0E-03	6.0E-03	6.0E-03
128	Pentachloronitrobenzene	82688	1.4E-02	1.4E+00			1.4E-02	1.4E+00	3.8E-06	3.8E-04	3.0E-03	3.8E-06	3.8E-04
129	Pentachlorophenol	87865	2.0E-01	2.0E+01	1.0E+02	2.5E+02	2.0E-01	2.0E+01	8.3E-06	8.3E-04	3.0E-02	8.3E-06	8.3E-04
130	Phenol	108952			6.0E+02	6.0E+03	6.0E+02	6.0E+02			6.0E-01	6.0E-01	6.0E-01
131	p-Phenylenediamine	106503									1.9E-01	1.9E-01	1.9E-01
132	Phosgene	75445			3.0E-01	4.0E+00	3.0E-01	3.0E-01					
133	Phosphine	7803512			3.0E-01	3.5E+02	3.0E-01	3.0E-01			3.0E-04	3.0E-04	3.0E-04
134	Phosphorus (white)	7723140											
135	Phthalic anhydride	85449			1.2E+02	6.0E+03	1.2E+02	1.2E+02			2.0E+00	2.0E+00	2.0E+00
136	Polychlorinated biphenyls (PCBs)	1336363	9.1E-03	9.1E-01			9.1E-03	9.1E-01	5.0E-07	5.0E-05		5.0E-07	5.0E-05
137	1,3-Propane sultone	1120714	1.4E-03	1.4E-01			1.4E-03	1.4E-01	4.2E-07	4.2E-05		4.2E-07	4.2E-05
138	beta-Propiolactone	57578											
139	Propionaldehyde	123386											
140	Baygon (propoxur)	114261									4.0E-03	4.0E-03	4.0E-03
141	1,2-Dichloropropane (propylene dichloride)	78875	5.3E-02	5.3E+00	4.0E+00	1.8E+05	5.3E-02	4.0E+00	1.5E-05	1.5E-03	9.0E-02	1.5E-05	1.5E-03
142	Propylene oxide	75569	2.7E-01	2.7E+01	3.0E+01	6.0E+03	2.7E-01	2.7E+01	4.2E-06	4.2E-04		4.2E-06	4.2E-04
143	1,2-Propylenimine (2-methyl aziridine)	75558											
144	Quinoline	91225	2.9E-04	2.9E-02			2.9E-04	2.9E-02	8.3E-08	8.3E-06		8.3E-08	8.3E-06
145	Quinone	106514				1.0E+04							
146	Styrene	100425			1.0E+03	2.0E+04	1.0E+03	1.0E+03			2.0E-01	2.0E-01	2.0E-01
147	Styrene oxide	96093			6.0E+00		6.0E+00	6.0E+00					
148	2,3,7,8-TCDD (dioxin)	1746016	3.0E-08	3.0E-06			3.0E-08	3.0E-06	6.7E-12	6.7E-10	1E-009	6.7E-12	6.7E-10
149	1,1,2,2-Tetrachloroethane	79345	1.7E-02	1.7E+00		6.9E+04	1.7E-02	1.7E+00	5.0E-06	5.0E-04	4.0E-02	5.0E-06	5.0E-04
150	Tetrachloroethylene (PCE)	127184	1.7E-01	1.7E+01	2.7E+02	1.0E+04	1.7E-01	1.7E+01	2.0E-05	2.0E-03	1.0E-02	2.0E-05	2.0E-03
151	Titanium tetrachloride	7550450			1.0E-01	5.0E+03	1.0E-01	1.0E-01					
152	Toluene	108883			4.0E+02	4.0E+04	4.0E+02	4.0E+02			2.0E-01	2.0E-01	2.0E-01
153	Toluene-2,4-diamine	95807	9.1E-04	9.1E-02			9.1E-04	9.1E-02	3.1E-07	3.1E-05		3.1E-07	3.1E-05
154	2,4/2,6-Toluene diisocyanate mixture	26471625	9.1E-02	9.1E+00	7.0E-02		7.0E-02	7.0E-02	2.6E-05	2.6E-03		2.6E-05	2.6E-03
155	2-Methylaniline (o-toluidine)	95534	2.0E-02	2.0E+00		2.2E+04	2.0E-02	2.0E+00	4.2E-06	4.2E-04		4.2E-06	4.2E-04
156	Toxaphene	8001352	3.1E-03	3.1E-01			3.1E-03	3.1E-01	9.1E-07	9.1E-05		9.1E-07	9.1E-05
157	1,2,4-Trichlorobenzene	120821			2.0E+02		2.0E+02	2.0E+02			1.0E-02	1.0E-02	1.0E-02
158	1,1,2-Trichloroethane	79005	6.3E-02	6.3E+00	4.0E+02	5.5E+04	6.3E-02	6.3E+00	1.8E-05	1.8E-03	4.0E-03	1.8E-05	1.8E-03
159	Trichloroethylene (TCE)	79016	5.0E-01	5.0E+01	6.0E+02	5.4E+05	5.0E-01	5.0E+01	6.7E-05	6.7E-03		6.7E-05	6.7E-03
160	2,4,5-Trichlorophenol	95954									1.0E-01	1.0E-01	1.0E-01
161	2,4,6-Trichlorophenol	88062	3.2E-01	3.2E+01			3.2E-01	3.2E+01	9.1E-05	9.1E-03		9.1E-05	9.1E-03
162	Triethylamine	121448			7.0E+00	3.0E+03	7.0E+00	7.0E+00					
163	Trifluralin	1582098	4.5E-01	4.5E+01			4.5E-01	4.5E+01	1.3E-04	1.3E-02	7.5E-03	1.3E-04	7.5E-03
164	2,2,4-Trimethylpentane	540841											

Table 2. Calculated risk-based concentrations (for inhalation) and risk-based doses (for oral exposure) used in ranking. Case 1: exposure at 1e-6 risk or HQ=1, whichever is less. Case 2: exposure at 1e-4 risk or HQ=1, whichever is less.

HAP			Risk-Based Concentrations for Inhalation						Risk-Based Doses for Ingestion				
			Cancer		Non-Cancer	Acute	Chronic RBCs Used for Indexing		Cancer		Non-Cancer	Chronic RBDs Used for Indexing	
			1.0E-06	1.0E-04					1.0E-06	1.0E-04			
No.	Contaminant	CAS #	ug/m3		ug/m3	ug/m3	Case 1	Case 2	mg/kg/d		mg/kg/d	Case 1	Case 2
165	Vinyl acetate	108054		.	2.0E+02	1.8E+04	2.0E+02	2.0E+02		.	1.0E+00	1.0E+00	1.0E+00
166	Vinyl bromide	593602	3.2E-02	3.2E+00	3.0E+00	.	3.2E-02	3.0E+00		.	.		
167	Vinyl chloride	75014	1.2E-02	1.2E+00	5.0E+00	2.0E+05	1.2E-02	1.2E+00	5.3E-07	5.3E-05	2E-005	5.3E-07	5.3E-05
168	1,1-Dichloroethylene	75354	2.0E-02	2.0E+00	2.0E+01	.	2.0E-02	2.0E+00	1.7E-06	1.7E-04	9.0E-03	1.7E-06	1.7E-04
169	Xylene (mixed)	1330207		.	4.3E+02	2.0E+03	4.3E+02	4.3E+02		.	2.0E+00	2.0E+00	2.0E+00
170	o-Xylene	95476		.	.	3.9E+05				.	2.0E+00	2.0E+00	2.0E+00
171	m-Xylene	108383		.	.	3.9E+05				.	2.0E+00	2.0E+00	2.0E+00
172	p-Xylene	106423		.	.	3.9E+05				.	.		
173	Antimony and compounds	7440360		.	2.0E-01	5.0E+03	2.0E-01	2.0E-01		.	4.0E-04	4.0E-04	4.0E-04
173	-Antimony pentafluoride	7783702		.	.	.				.	.		
173	-Antimony pentoxide	1314609		.	.	.				.	5.0E-04	5.0E-04	5.0E-04
173	-Antimony potassium tartrate	304610		.	.	.				.	9.0E-04	9.0E-04	9.0E-04
173	-Antimony tetroxide	1332816		.	.	.				.	4.0E-04	4.0E-04	4.0E-04
173	-Antimony trioxide	1309644		.	2.0E-01	.	2.0E-01	2.0E-01		.	4.0E-04	4.0E-04	4.0E-04
174	Arsenic and compounds	7440382	2.3E-04	2.3E-02	3.0E-02	4.0E-01	2.3E-04	2.3E-02	6.7E-07	6.7E-05	3.0E-04	6.7E-07	6.7E-05
174	-Arsine	7784421		.	5.0E-02	5.0E+02	5.0E-02	5.0E-02		.	.		
174	-Arsenic oxide	1327533		.	.	.				.	.		
174	-Arsenic pentoxide	1303282		.	.	.				.	.		
175	Beryllium and compounds	7440417	4.2E-04	4.2E-02	2.0E-02	2.5E+01	4.2E-04	2.0E-02		.	2.0E-03	2.0E-03	2.0E-03
176	Cadmium and compounds	7440439	5.6E-04	5.6E-02	1.0E-02	9.0E+03	5.6E-04	1.0E-02	6.7E-08	6.7E-06	5.0E-04	6.7E-08	6.7E-06
176	-Cadmium oxide	1306190		.	.	.				.	.		
177	Chromium III and compounds	16065831		.	.	2.5E+03				.	1.5E+00	1.5E+00	1.5E+00
177	Chromium VI and compounds	18540299	8.3E-05	8.3E-03	1.0E-01	1.5E+03	8.3E-05	8.3E-03	2.4E-06	2.4E-04	3.0E-03	2.4E-06	2.4E-04
177	-Chromic chloride	10025737		.	.	.				.	.		
178	Cobalt and compounds	7440484		.	.	2.0E+03				.	.		
178	-Cobalt carbonyl	10210681		.	.	.				.	.		
179	Coke Oven Emissions	8007452	1.6E-03	1.6E-01	.	.	1.6E-03	1.6E-01		.	.		
180	Cyanide compounds	57125		.	.	2.5E+03				.	2.0E-02	2.0E-02	2.0E-02
180	-Barium cyanide	542621		.	.	.				.	.		
180	-Calcium cyanide	592018		.	.	.				.	4.0E-02	4.0E-02	4.0E-02
180	-Chlorine cyanide	506774		.	.	1.0E+03				.	5.0E-02	5.0E-02	5.0E-02
180	-Copper cyanide	544923		.	.	.				.	5.0E-03	5.0E-03	5.0E-03
180	-Cyanazine	21725462	4.2E-03	4.2E-01	.	.	4.2E-03	4.2E-01	1.2E-06	1.2E-04	2.0E-03	1.2E-06	1.2E-04
180	-Cyanogen	460195		.	.	.				.	4.0E-02	4.0E-02	4.0E-02
180	-Cyanogen bromide	506683		.	.	.				.	9.0E-02	9.0E-02	9.0E-02
180	-Cyanogen chloride	506774		.	.	1.0E+03				.	5.0E-02	5.0E-02	5.0E-02
180	-Free cyanide	57125		.	.	2.5E+03				.	2.0E-02	2.0E-02	2.0E-02
180	-Hydrogen cyanide	74908		.	3.0E+00	3.0E+02	3.0E+00	3.0E+00		.	2.0E-02	2.0E-02	2.0E-02
180	-Potassium cyanide	151508		.	.	.				.	5.0E-02	5.0E-02	5.0E-02
180	-Potassium silver cyanide	506616		.	.	.				.	2.0E-01	2.0E-01	2.0E-01
180	-Silver cyanide	506649		.	.	.				.	1.0E-01	1.0E-01	1.0E-01
180	-Sodium cyanide	143339		.	.	.				.	4.0E-02	4.0E-02	4.0E-02

Table 2. Calculated risk-based concentrations (for inhalation) and risk-based doses (for oral exposure) used in ranking. Case 1: exposure at 1e-6 risk or HQ=1, whichever is less. Case 2: exposure at 1e-4 risk or HQ=1, whichever is less.

HAP No.	Contaminant	CAS #	Risk-Based Concentrations for Inhalation: Cancer 1.0E-06 (ug/m3)	Cancer 1.0E-04 (ug/m3)	Non-Cancer (ug/m3)	Acute (ug/m3)	Chronic RBCs Used for Indexing: Case 1	Case 2	Risk-Based Doses for Ingestion: Cancer 1.0E-06 (mg/kg/d)	Cancer 1.0E-04 (mg/kg/d)	Non-Cancer (mg/kg/d)	Chronic RBDs Used for Indexing: Case 1	Case 2
180	-Thiocyanate	THIOCYA		.	.	.				.	.		
180	-Zinc cyanide	557211		.	.	.				.	5.0E-02	5.0E-02	5.0E-02
181	Glycol ethers				2.0E+01		2.0E+01	2.0E+01			1.0E-03	1.0E-03	1.0E-03
181	-Diethylene glycol, monobutyl ether	112345		.	2.0E+01	.	2.0E+01	2.0E+01		.	.		
181	-Diethylene glycol, monoethyl ether	111900		.	.	.				.	2.0E+00	2.0E+00	2.0E+00
181	-2-Ethoxyethanol (ethylene glycol ethyl e	110805		.	2.0E+02	9.0E+02	2.0E+02	2.0E+02		.	4.0E-01	4.0E-01	4.0E-01
181	-Ethylene glycol monobutyl ether	111762		.	2.0E+01	1.0E+04	2.0E+01	2.0E+01		.	.		
181	-2-Methoxyethanol acetate	110496		.	9.0E+01	.	9.0E+01	9.0E+01		.	2.0E-03	2.0E-03	2.0E-03
181	-2-Methoxyethanol	109864		.	2.0E+01	2.0E+01	2.0E+01	2.0E+01		.	1.0E-03	1.0E-03	1.0E-03
182	Lead and lead compounds	7439921	8.3E-02	8.3E+00	1.5E+00	1.0E+04	8.3E-02	1.5E+00	1.2E-04	1.2E-02	.	1.2E-04	1.2E-02
182	-Tetramethyl lead	75741		.	.	4.0E+03				.	.		
182	-Tetraethyl lead	78002		.	.	4.0E+03				.	1E-007		
183	Manganese and compounds	7439965		.	5.0E-02	5.0E+04	5.0E-02	5.0E-02		.	2.3E-02	2.3E-02	2.3E-02
183	-Methylcyclopentadienyl manganese	12108133		.	.	.				.	.		
184	Mercury and compounds	7439976		.	3.0E-01	2.0E+00	3.0E-01	3.0E-01		.	1.0E-04	1.0E-04	1.0E-04
184	-Mercury (elemental)	7439976		.	3.0E-01	2.0E+00	3.0E-01	3.0E-01		.	1.0E-04	1.0E-04	1.0E-04
184	-Mercuric chloride	7487947		.	.	.				.	3.0E-04	3.0E-04	3.0E-04
184	-Mercury (methyl)	22967926		.	.	2.0E+02				.	1.0E-04	1.0E-04	1.0E-04
186	Nickel and compounds	7440020	8.3E-03	8.3E-01	2.0E-01	1.0E+01	8.3E-03	2.0E-01	1.1E-06	1.1E-04	2.0E-02	1.1E-06	1.1E-04
186	-Nickel refinery dust	NI_DUST	4.2E-03	4.2E-01	.	.	4.2E-03	4.2E-01		.	.		
186	-Nickel subsulfide	12035722	2.1E-03	2.1E-01	.	.	2.1E-03	2.1E-01		.	.		
187	Polycyclic Organic Matter	POM		.	.	.				.	.		
187	Carcinogenic PAHs: 7-PAH		3.0E-03	3.0E-01	.	.	3.0E-03	3.0E-01	4.1E-07	4.1E-05	-	4.1E-07	4.1E-05
187	-Acenaphthene	83329		.	.	.				.	6.0E-02	6.0E-02	6.0E-02
187	-Anthracene	120127		.	.	.				.	3.0E-01	3.0E-01	3.0E-01
187	-Benz[a]anthracene	56553	9.1E-03	9.1E-01	.	.	9.1E-03	9.1E-01	8.3E-07	8.3E-05	.	8.3E-07	8.3E-05
187	-Benzo[b]fluoranthene	205992	9.1E-03	9.1E-01	.	.	9.1E-03	9.1E-01	8.3E-07	8.3E-05	.	8.3E-07	8.3E-05
187	-Benzo[k]fluoranthene	207089	9.1E-03	9.1E-01	.	.	9.1E-03	9.1E-01	8.3E-07	8.3E-05	.	8.3E-07	8.3E-05
187	-Benzo[a]pyrene	50328	9.1E-04	9.1E-02	.	.	9.1E-04	9.1E-02	1.4E-07	1.4E-05	.	1.4E-07	1.4E-05
187	-Carbazole	86748	1.8E-01	1.8E+01	.	.	1.8E-01	1.8E+01	5.0E-05	5.0E-03	.	5.0E-05	5.0E-03
187	-Chrysene	218019	9.1E-02	9.1E+00	.	.	9.1E-02	9.1E+00	8.3E-06	8.3E-04	.	8.3E-06	8.3E-04
187	-Dibenz[a,h]acridine	226368	9.1E-03	9.1E-01	.	.	9.1E-03	9.1E-01	8.3E-07	8.3E-05	.	8.3E-07	8.3E-05
187	-Dibenz[a,j]acridine	224420	9.1E-03	9.1E-01	.	.	9.1E-03	9.1E-01	8.3E-07	8.3E-05	.	8.3E-07	8.3E-05
187	-Dibenz[a,h]anthracene	53703	2.6E-03	2.6E-01	.	.	2.6E-03	2.6E-01	2.4E-07	2.4E-05	.	2.4E-07	2.4E-05
187	-7H-Dibenzo[c,g]carbazole	194592	9.1E-04	9.1E-02	.	.	9.1E-04	9.1E-02	8.3E-08	8.3E-06	.	8.3E-08	8.3E-06
187	-Dibenzo[a,e]pyrene	192654	9.1E-04	9.1E-02	.	.	9.1E-04	9.1E-02	8.3E-08	8.3E-06	.	8.3E-08	8.3E-06
187	-Dibenzo[a,i]pyrene	189559	9.1E-05	9.1E-03	.	.	9.1E-05	9.1E-03	8.3E-09	8.3E-07	.	8.3E-09	8.3E-07
187	-Dibenzo[a,l]pyrene	191300	9.1E-05	9.1E-03	.	.	9.1E-05	9.1E-03	8.3E-09	8.3E-07	.	8.3E-09	8.3E-07
187	-7,12-Dimethylbenz[a]anthracene	57976	4.2E-05	4.2E-03	.	.	4.2E-05	4.2E-03	4.0E-09	4.0E-07	.	4.0E-09	4.0E-07
187	-1,6-Dinitropyrene	42397648	9.1E-05	9.1E-03	.	.	9.1E-05	9.1E-03	8.3E-09	8.3E-07	.	8.3E-09	8.3E-07
187	-1,8-Dinitropyrene	42397659	9.1E-04	9.1E-02	.	.	9.1E-04	9.1E-02	8.3E-08	8.3E-06	.	8.3E-08	8.3E-06
187	-Fluoranthene	206440		.	.	.				.	4.0E-02	4.0E-02	4.0E-02

Table 2. Calculated risk-based concentrations (for inhalation) and risk-based doses (for oral exposure) used in ranking. Case 1: exposure at 1e-6 risk or HQ=1, whichever is less. Case 2: exposure at 1e-4 risk or HQ=1, whichever is less.

			Risk-Based Concentrations for Inhalation						Risk-Based Doses for Ingestion				
			Cancer		Non-Cancer	Acute	Chronic RBCs Used for Indexing		Cancer		Non-Cancer	Chronic RBDs Used for Indexing	
HAP No.	Contaminant	CAS #	1.0E-06	1.0E-04	ug/m3	ug/m3	Case 1	Case 2	1.0E-06	1.0E-04	mg/kg/d	Case 1	Case 2
			ug/m3						mg/kg/d				
187	-Fluorene	86737		.	.	.				.	4.0E-02	4.0E-02	4.0E-02
187	-Hexachlorodibenzo-p-dioxin mixture	19408743	7.7E-07	7.7E-05	.	.	7.7E-07	7.7E-05	1.6E-10	1.6E-08	.	1.6E-10	1.6E-08
187	-Indeno[1,2,3-cd]pyrene	193395	9.1E-03	9.1E-01	.	.	9.1E-03	9.1E-01	8.3E-07	8.3E-05	.	8.3E-07	8.3E-05
187	-3-Methylcholanthrene	56495	4.8E-04	4.8E-02	.	.	4.8E-04	4.8E-02	4.5E-08	4.5E-06	.	4.5E-08	4.5E-06
187	-5-Methylchrysene	3697243	9.1E-04	9.1E-02	.	.	9.1E-04	9.1E-02	8.3E-08	8.3E-06	.	8.3E-08	8.3E-06
187	-2-Methylnaphthalene	91576		.	.	.				.	.		
187	-5-Nitroacenaphthene	602879	9.1E-02	9.1E+00	.	.	9.1E-02	9.1E+00	7.7E-06	7.7E-04	.	7.7E-06	7.7E-04
187	-6-Nitrochrysene	2043937	9.1E-05	9.1E-03	.	.	9.1E-05	9.1E-03	8.3E-09	8.3E-07	.	8.3E-09	8.3E-07
187	-2-Nitrofluorene	607578	9.1E-02	9.1E+00	.	.	9.1E-02	9.1E+00	7.7E-06	7.7E-04	.	7.7E-06	7.7E-04
187	-2-Nitrofluorene	607578	9.1E-02	9.1E+00	.	.	9.1E-02	9.1E+00	7.7E-06	7.7E-04	.	7.7E-06	7.7E-04
187	-1-Nitropyrene	5522430	9.1E-03	9.1E-01	.	.	9.1E-03	9.1E-01	8.3E-07	8.3E-05	.	8.3E-07	8.3E-05
187	-4-Nitropyrene	57835924	9.1E-03	9.1E-01	.	.	9.1E-03	9.1E-01	8.3E-07	8.3E-05	.	8.3E-07	8.3E-05
187	-Pyrene	129000		.	.	.				.	3.0E-02	3.0E-02	3.0E-02
189	Selenium	7782492		.	.	.				.	5.0E-03	5.0E-03	5.0E-03
189	-Hydrogen selenide	2148909		.	.	3.3E+02				.	.		
189	-Selenious Acid	7783008		.	.	.				.	5.0E-03	5.0E-03	5.0E-03
189	-Sodium selenate	13410010		.	.	.				.	.		
189	-Sodium selenite	10102188		.	.	.				.	.		

Key to Number Codes:

Prioritization of Dose-Response Sources for Chronic Exposure
1: IR=EPA Integrated Risk Information System (IRIS)
2: AT=ATSDR Minimum Risk Level (MRL)
3: HE=EPA Health Effects Assessment Summary Tables (HEAST)
4: CA=California EPA
99: CO=Inhalation value converted from oral
**: Staff judgment, described in TSD

Prioritization of Dose-Response Sources for Acute Exposure
1: NA=NAC Acute Exposure Guideline Level (1-hr Level I)
2: NA=NAC Acute Exposure Guideline Level (1-hr Level II)
3: CA=California EPA
4: AI=AIHA Emergency Removal Program Guidelines (1-hr Level 1)
5: AI=AIHA Emergency Removal Program Guidelines (1-hr Level II)
6: NI=10% of NIOSH Immediately Dangerous to Life or Health
7: AT=ATSDR Minimum Risk Level (MRL)

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Table 3. Emissions, ambient monitoring data, and bioconcentration factors used in ranking.

HAP No.	Contaminant	CAS #	Ambient Monitoring Data: Mean ug/m3	95th % ug/m3	No. of Sites	No. of Obs.	No. of Obs >=MDL	No. of States	No. of MSAs	NTI Emission Data: All Urban Sources t/y	Urban Area Sources Only t/y	% of Total from Area Sources	BAF/BCF unitless
1	Acetaldehyde	75070	2.5	4.5	73	8397	8166	17	29	7.88E+04	1.48E+04	18.8%	
2	Acetamide	60355								2.41E-02	1.53E-02	63.6%	
3	Acetonitrile	75058								8.92E+02	3.33E+01	3.7%	3.2E+00
4	Acetophenone	98862								2.33E+02	1.42E+01	6.1%	
5	2-Acetylaminofluorene	53963											5.0E+01
6	Acrolein	107028	0.052	0.17	20	1987	654	4	6	3.04E+04	2.03E+04	66.9%	3.2E+00
7	Acrylamide	79061								3.34E+01	3.04E+00	9.1%	9.8E-01
8	Acrylic acid	79107								4.99E+02	8.67E+00	1.7%	3.2E+00
9	Acrylonitrile	107131								2.24E+03	3.76E+02	16.8%	
10	Allyl chloride	107051								1.06E+02	1.27E+00	1.2%	
11	4-Aminobiphenyl	92671								1.36E-01	1.36E-03	1.0%	3.2E+01
12	Aniline	62533								3.82E+02	1.69E+01	4.4%	2.6E+00
13	o-Anisidine	90040								6.72E-01	4.62E-03	0.7%	
14	Asbestos*	1332214								6.50E+00	7.78E-01	12.0%	
15	Benzene	71432	3.3	8.1	198	78277	75971	23	50	2.56E+05	2.87E+04	11.2%	7.8E+00
16	Benzidine	92875								3.01E-01	3.09E-03	1.0%	2.1E+00
17	Benzotrichloride	98077								6.24E+00	6.41E-02	1.0%	
18	Benzyl chloride	100447								6.10E+01	1.14E+01	18.6%	
19	1,1-Biphenyl	92524	0.056	0.37	8	212	123	1	2	4.85E+02	1.31E+01	2.7%	
20	Bis(2-ethylhexyl)phthalate (DEHP)	117817	0.0058	0.014	8	212	49	1	2	5.74E+02	5.50E+01	9.6%	8.5E+02
21	Bis(chloromethyl)ether	542881								4.03E-01	5.42E-03	1.3%	3.2E+00
22	Bromoform (tribromomethane)	75252	0.005	0.008	18	649	28	12	14	7.24E+01	6.65E-01	0.9%	
23	1,3-Butadiene	106990	0.92	1.4	111	13476	6667	17	35	4.31E+04	5.74E+03	13.3%	
24	Calcium cyanamide	156627								6.31E+00	2.78E+00	44.0%	
25	Caprolactam	105602											
26	Captan	133062								1.88E+00			1.3E+01
27	Carbaryl	63252								8.01E-01	7.89E-01	98.5%	
28	Carbon disulfide	75150								7.57E+04	4.02E+03	5.3%	
29	Carbon tetrachloride	56235	0.9	1.2	164	21057	18310	20	44	3.33E+03	8.97E+01	2.7%	3.0E+01
30	Carbonyl sulfide	463581								1.02E+04	1.40E+03	13.8%	
31	Catechol	120809								1.27E+01	2.29E+00	18.0%	3.2E+00
32	Chloramben	133904											3.2E+00
33	Chlordane	57749								4.77E-02	7.65E-04	1.6%	2.2E+04
34	Chlorine	7782505								7.22E+04	4.37E+03	6.0%	
35	Chloroacetic acid	79118								3.02E+01	1.85E+00	6.1%	3.2E+00
36	2-Chloroacetophenone	532274								1.88E+00	1.06E-01	5.6%	8.7E-01
37	Chlorobenzene	108907	0.29	0.83	119	14702	5274	19	42	8.90E+03	7.48E+03	84.1%	
38	Chlorobenzilate	510156								2.01E+00			4.3E+02
39	Chloroform	67663	0.39	0.82	160	23126	11421	19	43	1.32E+04	5.04E+02	3.8%	6.0E+00
40	Chloromethyl methyl ether	107302								5.74E+00	1.57E-01	2.7%	
41	2-Chloro-1,3-butadiene (chloroprene)	126998	0.42	1.2	17	622	116	12	14	1.01E+03	9.32E-02	0.0%	
42	Cresols/cresylic acid (isomers and mixture)	1319773								6.21E+03	9.56E+00	0.2%	

Table 3. Emissions, ambient monitoring data, and bioconcentration factors used in ranking.

			Ambient Monitoring Data							NTI Emission Data			
HAP No.	Contaminant	CAS #	Mean ug/m3	95th % ug/m3	No. of Sites	No. of Obs.	No. of Obs >=MDL	No. of States	No. of MSAs	All Urban Sources t/y	Urban Area Sources Only t/y	% of Total from Area Sources	BAF/BCF unitless
43	2-Methylphenol (o-cresol)	95487											1.1E+01
44	3-Methylphenol (m-cresol)	108394											
45	4-Methylphenol (p-cresol)	106445											
46	Cumene	98828	0.26	0.69	49	49664	25365	9	17	7.25E+03	1.09E+02	1.5%	
47	2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757								2.50E+03	2.50E+03	100.0%	3.2E+00
48	DDE	72559	0.0024	0.0025	8	212		1	2				5.1E+04
49	Diazomethane	334883											6.9E+00
50	Dibenzofuran	132649	0.013	0.021	9	222	173	1	3	4.23E-02	2.32E-02	54.9%	1.3E+03
51	1,2-Dibromo-3-chloropropane	96128								1.12E+01	1.12E-01	1.0%	8.7E+00
52	Dibutyl phthalate	84742	0.0051	0.015	8	212	49	1	2	1.28E+02	1.62E+01	12.7%	2.1E+03
53	1,4-Dichlorobenzene	106467	1.8	5.2	93	9024	4288	20	38	4.25E+03	3.69E+03	86.7%	1.1E+02
54	3,3'-Dichlorobenzidine	91941								3.88E-01	3.92E-03	1.0%	
55	Bis(2-chloroethyl)ether	111444								3.68E+00	1.36E-01	3.7%	
56	1,3-Dichloropropene	542756	0.092	0.2	27	1590	805	13	17	1.67E+04	1.66E+04	99.8%	
57	Dichlorvos	62737								1.14E-01	1.00E-04	0.1%	
58	Diethanolamine	111422								1.28E+02	3.22E+00	2.5%	
59	N-N-Dimethylaniline	121697								2.32E+00	9.26E-03	0.4%	
60	Diethyl sulfate	64675								2.62E+00	3.53E-02	1.3%	
61	3,3'-Dimethoxybenzidine	119904								6.56E-01	6.56E-03	1.0%	4.9E+00
62	p-Dimethylaminoazobenzene	60117								2.31E-01	2.31E-03	1.0%	1.0E+01
63	3,3'-Dimethylbenzidine	119937								2.36E-01	2.36E-03	1.0%	2.9E+01
64	Dimethyl carbamoyl chloride	79447											
65	N,N-Dimethylformamide	68122								3.06E+03	1.64E+02	5.3%	
66	1,1-Dimethylhydrazine	57147								5.20E-01	1.14E-01	21.9%	3.2E+00
67	Dimethyl phthalate	131113								3.25E+01	4.12E+00	12.7%	
68	Dimethyl sulfate	77781								4.51E+00	8.34E-01	18.5%	
69	4,6-Dinitro-2-methylphenol	534521								4.45E-01	4.14E-03	0.9%	1.4E+00
70	2,4-Dinitrophenol	51285								7.22E+00	4.80E-02	0.7%	3.7E+00
71	Dinitrotoluene mixture	25321146											8.3E+00
71	2,4-Dinitrotoluene	121142								4.55E-01	8.23E-03	1.8%	
72	1,4-Dioxane	123911								7.11E+02	4.33E+01	6.1%	
73	1,2-Diphenylhydrazine	122667											3.6E+01
74	Epichlorohydrin	106898								3.22E+02	7.36E+00	2.3%	3.2E+00
75	1,2-Epoxybutane	106887								4.49E+01	1.40E+00	3.1%	
76	Ethyl acrylate	140885								1.50E+02	1.88E+01	12.5%	
77	Ethylbenzene	100414	1.3	3.2	172	72264	62360	24	51	7.76E+04	4.06E+03	5.2%	
78	Ethyl carbamate (urethane)	51796								7.99E+00	2.45E+00	30.6%	
79	Chloroethane (ethyl chloride)	75003	0.27	0.86	43	3508	1125	16	21	1.79E+03	1.17E+02	6.6%	2.5E+00
80	1,2-Dibromoethane	106934	0.43	0.44	96	14248	2876	8	28	3.05E+01	4.67E-01	1.5%	7.2E+00
81	1,2-Dichloroethane (EDC)	107062	1.3	4.5	154	20479	5627	19	41	2.76E+03	8.14E+01	2.9%	2.0E+00
82	Ethylene glycol	107211								9.51E+03	6.23E+02	6.6%	
83	Ethylene imine (aziridine)	151564											

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84	Ethylene oxide	75218								2.15E+03	1.14E+03	53.0%	3.2E+00 [4]
85	Ethylene thiourea (ETU)	96457								1.82E+00	8.31E-02	4.6%	1.0E+01 [2]
86	1,1-Dichloroethane	75343	0.095	0.22	72	8073	3605	17	28	3.84E+03	2.22E+02	5.8%	4.8E+00 [4]
87	Formaldehyde	50000	2.8	5	82	10209	9946	17	30	2.05E+05	4.85E+04	23.7%	
88	Heptachlor	76448	0.0024	0.0025	8	212		1	2	2.90E-02	4.65E-04	1.6%	2.0E+04 [2]
89	Hexachlorobenzene	118741	0.0024	0.0025	8	212		1	2	2.07E+00	4.61E-01	22.3%	1.9E+04 [2]
90	Hexachlorobutadiene	87683	0.099	0.23	31	2950	1128	7	10	1.32E+01	1.33E-01	1.0%	6.9E+03 [2]
91	Hexachlorocyclopentadiene	77474	0.0025	0.0025	8	212		1	2	3.80E+00	4.75E-02	1.3%	4.0E+02 [2]
92	Hexachloroethane	67721	0.0024	0.0025	8	212		1	2	2.55E+01	1.31E+01	51.3%	7.1E+02 [2]
93	Hexamethylene-1,6-diisocyanate	822060								1.40E-01	1.33E-01	94.9%	
94	Hexamethylphosphoramide	680319											
95	n-Hexane	110543	2.3	5.3	61	51964	50606	12	19	1.23E+05	3.71E+04	30.2%	
96	Hydrazine, hydrazine sulfate	302012								1.24E+01	9.88E-01	8.0%	
97	Hydrogen chloride	7647010	1.9	2.1	8	816	230	2	1	1.88E+06	6.06E+04	3.2%	
98	Hydrogen fluoride	7664393	0.055	0.086	7	1330	1330	1		2.89E+04	2.15E+03	7.4%	
99	Hydroquinone	123319								7.06E+01	6.69E-01	0.9%	
100	Isophorone	78591								3.08E+02	1.08E+02	35.0%	
101	alpha-Hexachlorocyclohexane (a-HCH)	319846											7.1E+02 [2]
101	beta-Hexachlorocyclohexane (b-HCH)	319857											3.0E+02 [2]
101	gamma-Hexachlorocyclohexane (g-HCH,Lindane	58899											3.3E+04 [1]
101	technical Hexachlorocyclohexane (HCH)	608731											5.0E+02 [2]
102	Maleic anhydride	108316								1.92E+02	8.24E-01	0.4%	
103	Methanol	67561								2.61E+05	8.08E+04	31.0%	
104	Methoxychlor	72435								4.80E-02	3.84E-03	8.0%	8.1E+03 [2]
105	Bromomethane (methyl bromide)	74839	0.94	0.39	68	6028	2116	17	26	2.49E+04	2.31E+04	93.0%	1.7E+00 [4]
106	Chloromethane (methyl chloride)	74873	1.2	4.1	55	5728	4551	17	24	5.37E+03	6.71E+01	1.2%	3.2E+00 [4]
107	1,1,1-Trichloroethane	71556	3.3	12	161	20317	19650	21	46	2.34E+05	7.54E+04	32.2%	8.9E+00 [2]
108	Methyl ethyl ketone	78933	1.5	3.7	34	3156	2420	3	12	1.89E+05	1.47E+04	7.8%	
109	Methyl hydrazine	60344								8.31E+00	2.62E+00	31.6%	
110	Methyl iodide	74884								3.78E+01	1.08E+00	2.9%	2.9E+00 [4]
111	Methyl isobutyl ketone	108101	2.3	7.1	4	219	104	1	1	3.19E+04	5.22E+03	16.4%	
112	Methyl isocyanate	624839								4.93E+00	2.10E-01	4.2%	3.2E+00 [4]
113	Methyl methacrylate	80626								1.45E+03	8.53E+01	5.9%	
114	Methyl tertbutyl ether (MTBE)	1634044	5	12	18	966	720	1	1	1.06E+04	5.59E+03	52.5%	
115	4,4'-Methylene bis(2-chloroaniline)	101144								6.16E-01	1.51E-02	2.5%	1.7E+02 [2]
116	Methylene chloride	75092	3.1	9.8	165	23166	12139	21	46	9.08E+04	1.61E+04	17.7%	1.6E+01 [2]
117	4,4'-Methylenediphenyl diisocyanate	101688								1.12E+02	5.49E+01	49.0%	2.1E+03 [4]
118	4,4'-Methylenedianiline	101779								3.63E+00	1.95E-01	5.4%	6.9E+00 [2]
119	Naphthalene	91203	0.63	2	11	274	202	2	2	2.04E+03	3.80E+02	18.6%	4.3E+02 [2]
120	Nitrobenzene	98953								4.30E+01	4.11E-01	1.0%	1.5E+01 [2]
121	4-Nitrobiphenyl	92933								2.79E-01	2.79E-03	1.0%	1.7E+02 [4]
122	4-Nitrophenol	100027								1.27E+00	3.09E-02	2.4%	

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123	2-Nitropropane	79469								5.21E+01	1.10E+00	2.1%	8.3E+00
124	N-Nitroso-N-methylurea	684935											
125	N-Nitrosodimethylamine	62759								2.21E+01	8.99E-01	4.1%	3.2E+00
126	N-Nitrosomorpholine	59892								4.71E-01	4.71E-03	1.0%	
127	Parathion	56382								6.08E-01	4.86E-02	8.0%	1.6E+02
128	Pentachloronitrobenzene	82688								1.73E+00	5.36E-02	3.1%	1.1E+03
129	Pentachlorophenol	87865								2.68E+00	1.54E+00	57.6%	7.8E+02
130	Phenol	108952	0.062	0.25	8	212	72	1	2	8.20E+03	4.37E+02	5.3%	2.0E+01
131	p-Phenylenediamine	106503								1.84E+00	4.87E-03	0.3%	
132	Phosgene	75445								3.98E+00	9.04E-02	2.3%	3.2E+00
133	Phosphine	7803512								3.13E+00	1.11E+00	35.5%	
134	Phosphorus (white)	7723140											
135	Phthalic anhydride	85449								4.79E+02	3.84E+01	8.0%	
136	Polychlorinated biphenyls (PCBs)	1336363	0.0005	0.0007	3	30	30	1		2.63E-02	5.23E-03	19.9%	2.9E+07
137	1,3-Propane sultone	1120714								7.21E-04	5.05E-04	70.0%	
138	beta-Propiolactone	57578											
139	Propionaldehyde	123386	0.94	2.3	23	1914	1848	5	8	5.09E+03	1.07E+01	0.2%	
140	Baygon (propoxur)	114261								5.00E-03	1.50E-04	3.0%	3.0E+00
141	1,2-Dichloropropane (propylene dichloride)	78875	0.32	1.3	68	8061	1310	17	28	5.42E+02	1.93E+01	3.6%	
142	Propylene oxide	75569								2.99E+03	4.31E+02	14.4%	
143	1,2-Propylenimine (2-methyl aziridine)	75558								4.04E-01	6.64E-03	1.6%	
144	Quinoline	91225								2.32E+01	1.46E+00	6.3%	
145	Quinone	106514								7.00E+00			
146	Styrene	100425	0.71	2.5	117	58229	34358	14	37	3.95E+04	2.39E+03	6.1%	
147	Styrene oxide	96093								1.75E-01	3.44E-03	2.0%	
148	2,3,7,8-TCDD (dioxin)	1746016								2.46E-03	5.77E-04	23.5%	5.8E+03
149	1,1,2,2-Tetrachloroethane	79345	0.084	0.44	46	3741	1039	17	23	2.18E+02	1.74E+02	79.5%	
150	Tetrachloroethylene (PCE)	127184	1.4	5.1	160	22784	16782	21	44	1.03E+05	8.42E+04	81.4%	4.9E+01
151	Titanium tetrachloride	7550450								5.04E+00	4.76E-02	0.9%	
152	Toluene	108883	8.7	22	197	76600	75939	23	50	8.01E+05	2.02E+05	25.2%	
153	Toluene-2,4-diamine	95807								5.44E+01	3.56E+00	6.5%	
154	2,4/2,6-Toluene diisocyanate mixture	26471625								8.64E+00	2.25E-01	2.6%	
155	2-Methylaniline (o-toluidine)	95534											
156	Toxaphene	8001352											4.2E+07
157	1,2,4-Trichlorobenzene	120821	0.13	0.48	23	2190	652	6	8	3.23E+03	1.49E+01	0.5%	2.1E+03
158	1,1,2-Trichloroethane	79005	0.11	0.55	80	6383	3030	18	29	4.93E+02	5.05E+00	1.0%	4.3E+00
159	Trichloroethylene (TCE)	79016	0.69	2	144	19050	9529	21	44	6.65E+04	1.28E+04	19.3%	
160	2,4,5-Trichlorophenol	95954								3.91E-01	3.91E-03	1.0%	1.9E+03
161	2,4,6-Trichlorophenol	88062								4.66E-01	5.44E-03	1.2%	
162	Triethylamine	121448								5.50E+02	2.50E+02	45.4%	
163	Trifluralin	1582098								9.09E+00	4.17E-01	4.6%	4.2E+03
164	2,2,4-Trimethylpentane	540841	1.7	4.7	49	49786	45458	9	17	2.55E+04	3.81E+03	14.9%	2.8E+02

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165	Vinyl acetate	108054								3.24E+03	6.19E+01	1.9%	
166	Vinyl bromide	593602								1.32E+00			
167	Vinyl chloride	75014	0.49	2	114	15471	3337	19	31	2.42E+03	4.89E+02	20.2%	3.5E+00
168	1,1-Dichloroethylene	75354	0.11	0.47	54	7417	3895	7	19	2.08E+02	4.00E+01	19.3%	
169	Xylene (mixed)	1330207	11	11	1	22	16	1	1	4.38E+05	8.14E+04	18.6%	
170	o-Xylene	95476	2.4	7.9	154	71291	64552	18	44				
171	m-Xylene	108383	4.3	8.9	42	11813	10647	8	18				
172	p-Xylene	106423	2.2	4.5	25	1958	806	2	11				
173	Antimony and compounds	7440360	0.0022	0.0035	22	4084	4084	1	8	1.08E+02	2.39E+01	22.0%	3.2E+00
173	-Antimony pentafluoride	7783702											
173	-Antimony pentoxide	1314609											
173	-Antimony potassium tartrate	304610											
173	-Antimony tetroxide	1332816											
173	-Antimony trioxide	1309644								1.77E+01	5.02E+00	28.4%	
174	Arsenic and compounds	7440382	0.0011	0.0013	28	6516	6516	1	8	1.98E+02	3.25E+01	16.4%	4.0E+00
174	-Arsine	7784421											
174	-Arsenic oxide	1327533											
174	-Arsenic pentoxide	1303282											
175	Beryllium and compounds	7440417								8.29E+00	2.29E+00	27.7%	1.9E+01
176	Cadmium and compounds	7440439	0.0025	0.0025	1	55	55	1		1.66E+02	3.18E+01	19.1%	1.9E+02
176	-Cadmium oxide	1306190											
177	Chromium III and compounds	16065831								4.92E+02	2.18E+02	44.2%	
177	Chromium VI and compounds	18540299	0.0058	0.02	25	3620	1583	1	10	2.65E+02	1.17E+02	44.2%	
177	-Chromic chloride	10025737											
178	Cobalt and compounds	7440484	0.003	0.003	28	6516	6516	1	8	1.06E+02	3.43E+01	32.3%	
178	-Cobalt carbonyl	10210681											
179	Coke Oven Emissions	8007452								1.57E+03			
180	Cyanide compounds	57125								2.43E+03	1.42E+03	58.5%	3.2E+00
180	-Barium cyanide	542621											
180	-Calcium cyanide	592018											
180	-Chlorine cyanide	506774											
180	-Copper cyanide	544923											
180	-Cyanazine	21725462											4.9E+00
180	-Cyanogen	460195											
180	-Cyanogen bromide	506683											
180	-Cyanogen chloride	506774											
180	-Free cyanide	57125											3.2E+00
180	-Hydrogen cyanide	74908											3.2E+00
180	-Potassium cyanide	151508											
180	-Potassium silver cyanide	506616											
180	-Silver cyanide	506649											
180	-Sodium cyanide	143339											

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180	-Thiocyanate	THIOCYA											
180	-Zinc cyanide	557211											
181	Glycol ethers									5.68E+04	9.64E+03	17.0%	
181	-Diethylene glycol, monobutyl ether	112345											
181	-Diethylene glycol, monoethyl ether	111900											
181	-2-Ethoxyethanol (ethylene glycol ethyl e	110805											
181	-Ethylene glycol monobutyl ether	111762											
181	-2-Methoxyethanol acetate	110496											
181	-2-Methoxyethanol	109864											
182	Lead and lead compounds	7439921	0.0063	0.018	27	5456	5456	1	8	2.74E+03	4.57E+02	16.7%	1.7E+03
182	-Tetramethyl lead	75741											
182	-Tetraethyl lead	78002								5.23E-01	3.53E-01	67.5%	1.1E+03
183	Manganese and compounds	7439965	0.0031	0.007	28	6395	6395	1	8	1.93E+03	5.05E+02	26.1%	
183	-Methylcyclopentadienyl manganese	12108133											
184	Mercury and compounds	7439976	0.001	0.0011	28	6395	6395	1	8	1.52E+02	5.25E+01	34.5%	6.8E+06
184	-Mercury (elemental)	7439976											6.8E+06
184	-Mercuric chloride	7487947											
184	-Mercury (methyl)	22967926											6.8E+06
186	Nickel and compounds	7440020	0.0011	0.0033	28	6393	6393	1	8	1.12E+03	3.69E+02	33.0%	1.0E+00
186	-Nickel refinery dust	NI_DUST											
186	-Nickel subsulfide	12035722											
187	Polycyclic Organic Matter	POM											
187	Carcinogenic PAHs: 7-PAH		2.3075	4.9226						5.13E+02	3.17E+02	61.8%	8.0E+02
187	-Acenaphthene	83329	0.0095	0.021	11	284	211	2	2	1.04E-02	1.04E-02	100.0%	3.9E+02
187	-Anthracene	120127	0.0019	0.0026	11	284	33	2	2	2.22E+01	7.96E+00	35.9%	6.0E+02
187	-Benz[a]anthracene	56553								1.12E-01	2.78E-02	24.8%	8.0E+02
187	-Benzo[b]fluoranthene	205992	0.0012	0.0025	30	3239	1813	2	12	8.51E-02	6.85E-03	8.0%	5.6E+03
187	-Benzo[k]fluoranthene	207089	0.001	0.0025	30	3239	1157	2	12	8.69E-02	8.38E-03	9.6%	1.0E+04
187	-Benzo[a]pyrene	50328	2.3	4.9	18	470	258	9	11	1.38E-01	1.96E-02	14.2%	9.1E+02
187	-Carbazole	86748											5.0E+02
187	-Chrysene	218019								8.93E-02	2.57E-02	28.8%	8.0E+02
187	-Dibenz[a,h]acridine	226368											1.0E+02
187	-Dibenz[a,j]acridine	224420								3.47E-05	1.91E-05	55.0%	1.9E+04
187	-Dibenz[a,h]anthracene	53703	0.0041	0.015	30	2818	378	2	12	1.10E-01	1.25E-02	11.4%	4.6E+04
187	-7H-Dibenzo[c,g]carbazole	194592											1.7E+04
187	-Dibenzo[a,e]pyrene	192654								1.51E-03			6.9E+03
187	-Dibenzo[a,i]pyrene	189559											2.6E+04
187	-Dibenzo[a,l]pyrene	191300											
187	-7,12-Dimethylbenz[a]anthracene	57976											5.9E+03
187	-1,6-Dinitropyrene	42397648											
187	-1,8-Dinitropyrene	42397659											
187	-Fluoranthene	206440	0.0031	0.0084	11	284	110	2	2	2.02E-02	2.02E-02	100.0%	5.1E+03

Table 3. Emissions, ambient monitoring data, and bioconcentration factors used in ranking.

HAP			Ambient Monitoring Data							NTI Emission Data			
			Mean	95th %	No. of	No. of	No. of Obs	No. of	No. of	All Urban Sources	Urban Area Sources Only	% of Total from Area	BAF/BCF
No.	Contaminant	CAS #	ug/m3	ug/m3	Sites	Obs.	>=MDL	States	MSAs	t/y	t/y	Sources	unitless
187	-Fluorene	86737								2.00E-02	2.00E-02	100.0%	1.3E+03 2
187	-Hexachlorodibenzo-p-dioxin mixture	19408743								1.22E-04	1.22E-05	10.0%	
187	-Indeno[1,2,3-cd]pyrene	193395	0.0012	0.0026	31	2929	1551	2	12	1.01E-01	8.65E-03	8.6%	2.9E+04 4
187	-3-Methylcholanthrene	56495											1.7E+04 4
187	-5-Methylchrysene	3697243											
187	-2-Methylnaphthalene	91576											1.9E+02 2
187	-5-Nitroacenaphthene	602879											
187	-6-Nitrochrysene	2043937											
187	-2-Nitrofluorene	607578											
187	-2-Nitrofluorene	607578											
187	-1-Nitropyrene	5522430											
187	-4-Nitropyrene	57835924											
187	-Pyrene	129000	0.0024	0.006	11	284	81	2	2	2.00E-02	2.00E-02	100.0%	7.8E+02 2
189	Selenium	7782492								5.17E+02	9.42E+01	18.2%	8.8E+01 2
189	-Hydrogen selenide	2148909											
189	-Selenious Acid	7783008											
189	-Sodium selenate	13410010											
189	-Sodium selenite	10102188											

Key to Number Codes:

Prioritization of Sources of WMPT BAF/BCFs

1: HWIR or Mercury Study measured BAF

2: HWIR, ISIS, or AWQS measured BCF

3: HWIR predicted BAF

4: HWIR or BCFWIN predicted BCF

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Table 4. Raw ranking index scores, by HAP.

HAP No.	Contaminant	CAS #	Index 1: Measured Max./ Acute RBC	Index 2: Measured Avg./ Chronic RBC		Index 3: NTI Urban Emissions/ Chronic RBC		Index 4: NTI * BCF/ Chronic RBD	
				Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
1	Acetaldehyde	75070	2.50E-04	5.50E+00	2.78E-01	1.73E+05	8.76E+03		
2	Acetamide	60355				4.83E-01	4.83E-03		
3	Acetonitrile	75058				1.78E+01	1.78E+01	4.70E+05	4.70E+05
4	Acetophenone	98862							
5	2-Acetylaminofluorene	53963							
6	Acrolein	107028	4.25E-01	2.60E+00	2.60E+00	1.52E+06	1.52E+06	1.92E+08	1.92E+08
7	Acrylamide	79061				4.34E+04	4.34E+02	1.47E+08	1.47E+06
8	Acrylic acid	79107				4.99E+02	4.99E+02	3.16E+03	3.16E+03
9	Acrylonitrile	107131				1.52E+05	1.52E+03		
10	Allyl chloride	107051				6.34E+02	1.06E+02		
11	4-Aminobiphenyl	92671							
12	Aniline	62533				6.12E+02	3.82E+02	5.60E+06	5.60E+04
13	o-Anisidine	90040							
14	Asbestos*	1332214							
15	Benzene	71432	1.01E-02	2.57E+01	2.57E-01	2.00E+06	2.00E+04	5.77E+10	5.77E+08
16	Benzidine	92875				2.02E+04	2.02E+02	1.48E+08	1.48E+06
17	Benzotrichloride	98077				2.31E+04	2.31E+02		
18	Benzyl chloride	100447				2.99E+03	2.99E+01		
19	1,1-Biphenyl	92524							
20	Bis(2-ethylhexyl)phthalate (DEHP)	117817		1.39E-02	5.80E-04	1.38E+03	5.74E+01	6.84E+09	6.84E+07
21	Bis(chloromethyl)ether	542881				2.50E+04	2.50E+02	2.80E+08	2.80E+06
22	Bromoform (tribromomethane)	75252	9.09E-09	5.50E-03	5.50E-05	7.97E+01	7.97E-01		
23	1,3-Butadiene	106990	6.36E-05	2.58E+02	2.58E+00	1.21E+07	1.21E+05		
24	Calcium cyanamide	156627							
25	Caprolactam	105602							
26	Captan	133062				1.88E+00	1.88E-02	8.48E+04	8.48E+02
27	Carbaryl	63252							
28	Carbon disulfide	75150				1.08E+02	1.08E+02		
29	Carbon tetrachloride	56235	2.40E-04	1.35E+01	1.35E-01	4.99E+04	4.99E+02	1.31E+10	1.44E+08
30	Carbonyl sulfide	463581							
31	Catechol	120809							
32	Chloramben	133904							
33	Chlordane	57749				4.77E+00	6.81E-02	3.65E+08	3.65E+06
34	Chlorine	7782505				3.61E+03	3.61E+03		
35	Chloroacetic acid	79118						4.77E+04	4.77E+04
36	2-Chloroacetophenone	532274				6.28E+01	6.28E+01		
37	Chlorobenzene	108907	1.80E-06	1.45E-02	1.45E-02	4.45E+02	4.45E+02		
38	Chlorobenzilate	510156				1.55E+02	1.55E+00	2.32E+08	2.32E+06
39	Chloroform	67663	2.05E-03	8.97E+00	8.97E-02	3.04E+05	3.04E+03	4.86E+08	7.96E+06
40	Chloromethyl methyl ether	107302							
41	2-Chloro-1,3-butadiene (chloroprene)	126998	1.09E-05	6.00E-02	6.00E-02	1.45E+02	1.45E+02		
42	Cresols/cresylic acid (isomers and mixture)	1319773				1.55E+03	1.55E+03		

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Table 4. Raw ranking index scores, by HAP.

HAP No.	Contaminant	CAS #	Index 1: Measured Max./ Acute RBC	Index 2: Measured Avg./ Chronic RBC		Index 3: NTI Urban Emissions/ Chronic RBC		Index 4: NTI * BCF/ Chronic RBD	
				Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
43	2-Methylphenol (o-cresol)	95487							
44	3-Methylphenol (m-cresol)	108394							
45	4-Methylphenol (p-cresol)	106445							
46	Cumene	98828	1.57E-06	6.50E-04	6.50E-04	1.81E+01	1.81E+01		
47	2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757						7.92E+05	7.92E+05
48	DDE	72559		2.33E-01	2.33E-03				
49	Diazomethane	334883							
50	Dibenzofuran	132649							
51	1,2-Dibromo-3-chloropropane	96128				5.59E+01	5.59E+01	1.36E+08	1.36E+06
52	Dibutyl phthalate	84742	3.75E-08					2.74E+06	2.74E+06
53	1,4-Dichlorobenzene	106467	5.78E-05	2.25E-03	2.25E-03	5.31E+00	5.31E+00	1.14E+10	1.14E+08
54	3,3'-Dichlorobenzidine	91941				1.32E+02	1.32E+00		
55	Bis(2-chloroethyl)ether	111444				1.22E+03	1.22E+01		
56	1,3-Dichloropropene	542756		3.40E+00	3.40E-02	6.16E+05	6.16E+03		
57	Dichlorvos	62737				9.43E+00	2.27E-01		
58	Diethanolamine	111422				6.39E+00	6.39E+00		
59	N-N-Dimethylaniline	121697							
60	Diethyl sulfate	64675							
61	3,3'-Dimethoxybenzidine	119904				2.63E+00	2.63E-02	4.50E+04	4.50E+02
62	p-Dimethylaminoazobenzene	60117				3.00E+02	3.00E+00	1.06E+07	1.06E+05
63	3,3'-Dimethylbenzidine	119937				6.15E+02	6.15E+00	6.27E+07	6.27E+05
64	Dimethyl carbamoyl chloride	79447							
65	N,N-Dimethylformamide	68122				1.02E+02	1.02E+02		
66	1,1-Dimethylhydrazine	57147							
67	Dimethyl phthalate	131113							
68	Dimethyl sulfate	77781							
69	4,6-Dinitro-2-methylphenol	534521							
70	2,4-Dinitrophenol	51285						1.34E+04	1.34E+04
71	Dinitrotoluene mixture	25321146							
71	2,4-Dinitrotoluene	121142				4.05E+01	4.05E-01		
72	1,4-Dioxane	123911				5.47E+03	5.47E+01		
73	1,2-Diphenylhydrazine	122667							
74	Epichlorohydrin	106898				3.86E+02	3.22E+02	1.01E+07	5.09E+05
75	1,2-Epoxybutane	106887				2.24E+00	2.24E+00		
76	Ethyl acrylate	140885				2.10E+03	2.10E+01		
77	Ethylbenzene	100414	9.14E-06	1.30E-03	1.30E-03	7.76E+01	7.76E+01		
78	Ethyl carbamate (urethane)	51796				2.32E+03	2.32E+01		
79	Chloroethane (ethyl chloride)	75003	8.60E-07	2.70E-05	2.70E-05	1.79E-01	1.79E-01		
80	1,2-Dibromoethane	106934	5.71E-06	9.46E+01	2.15E+00	6.71E+03	1.52E+02	1.88E+10	1.88E+08
81	1,2-Dichloroethane (EDC)	107062	2.25E-04	3.38E+01	3.38E-01	7.18E+04	7.18E+02	5.01E+08	5.01E+06
82	Ethylene glycol	107211				2.38E+01	2.38E+01		
83	Ethylene imine (aziridine)	151564							

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				Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
84	Ethylene oxide	75218				2.15E+05	2.15E+03	6.80E+09	6 80E+07
85	Ethylene thiourea (ETU)	96457				2.36E+01	6 06E-01	2.18E+06	2 18E+04
86	1,1-Dichloroethane	75343	1.83E-07	1.52E-01	1.52E-03	6.15E+03	6.15E+01	1.05E+08	1 05E+06
87	Formaldehyde	50000	1.67E-02	3.64E+01	7.57E-01	2.66E+06	5.53E+04		
88	Heptachlor	76448	7.14E-07	3.12E+00	3.12E-02	3.77E+01	3.77E-01	2.60E+09	2 60E+07
89	Hexachlorobenzene	118741		1.10E+00	1.10E-02	9.52E+02	9.52E+00	6.17E+10	6 17E+08
90	Hexachlorobutadiene	87683	7.19E-06	2.18E+00	2.18E-02	2.90E+02	2.90E+00	7.12E+09	4 56E+08
91	Hexachlorocyclopentadiene	77474		7.58E-03	7.58E-03	1.15E+01	1.15E+01	2.17E+05	2 17E+05
92	Hexachloroethane	67721	4.31E-08	9.60E-03	9.60E-05	1.02E+02	1.02E+00	2.53E+08	1 81E+07
93	Hexamethylene-1,6-diisocyanate	822060				1.40E+01	1.40E+01		
94	Hexamethylphosphoramide	680319							
95	n-Hexane	110543	1.36E-05	1.15E-02	1.15E-02	6.15E+02	6.15E+02		
96	Hydrazine, hydrazine sulfate	302012				6.08E+04	6.08E+02		
97	Hydrogen chloride	7647010	1.05E-03	9.50E-02	9.50E-02	9.41E+04	9.41E+04		
98	Hydrogen fluoride	7664393	4.30E-04	1.83E-03	1.83E-03	9.64E+02	9.64E+02		
99	Hydroquinone	123319							
100	Isophorone	78591				8.31E+01	8.31E-01		
101	alpha-Hexachlorocyclohexane (a-HCH)	319846							
101	beta-Hexachlorocyclohexane (b-HCH)	319857							
101	gamma-Hexachlorocyclohexane (g-HCH,Lindane	58899							
101	technical Hexachlorocyclohexane (HCH)	608731							
102	Maleic anhydride	108316				9.61E+02	9.61E+02		
103	Methanol	67561				2.61E+01	2.61E+01		
104	Methoxychlor	72435						7.80E+04	7 80E+04
105	Bromomethane (methyl bromide)	74839	9.75E-05	1.88E-01	1.88E-01	4.97E+03	4.97E+03	2.95E+07	2 95E+07
106	Chloromethane (methyl chloride)	74873	4.94E-06	2.16E+00	2.16E-02	9.67E+03	9.67E+01	2 21E+08	2 21E+06
107	1,1,1-Trichloroethane	71556	1.71E-03	3.30E-03	3.30E-03	2.34E+02	2.34E+02		
108	Methyl ethyl ketone	78933	5.29E-05	1.50E-03	1.50E-03	1.89E+02	1.89E+02		
109	Methyl hydrazine	60344							
110	Methyl iodide	74884							
111	Methyl isobutyl ketone	108101		2.88E-02	2.88E-02	3.98E+02	3.98E+02		
112	Methyl isocyanate	624839				4.93E+00	4.93E+00		
113	Methyl methacrylate	80626				2.07E+00	2.07E+00		
114	Methyl tertbutyl ether (MTBE)	1634044	1.67E-03	1.67E-03	1.67E-03	3.55E+00	3.55E+00		
115	4,4'-Methylene bis(2-chloroaniline)	101144				2.28E+01	2.28E-01	1.33E+07	1 33E+05
116	Methylene chloride	75092	1.23E-03	1.46E+00	1.46E-02	4.27E+04	4.27E+02	1.10E+10	1 10E+08
117	4,4'-Methylenediphenyl diisocyanate	101688				1.87E+02	1.87E+02		
118	4,4'-Methylenedianiline	101779				1.67E+03	1.67E+01	4.02E+07	4 02E+05
119	Naphthalene	91203	1.54E-05	2.10E-01	2.10E-01	6.80E+02	6.80E+02	4.35E+07	4 35E+07
120	Nitrobenzene	98953				2.15E+01	2.15E+01	1.30E+06	1 30E+06
121	4-Nitrobiphenyl	92933							
122	4-Nitrophenol	100027							

Table 4. Raw ranking index scores, by HAP.

HAP No.	Contaminant	CAS #	Index 1: Measured Max./ Acute RBC	Index 2: Measured Avg./ Chronic RBC		Index 3: NTI Urban Emissions/ Chronic RBC		Index 4: NTI * BCF/ Chronic RBD	
				Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
123	2-Nitropropane	79469				1.41E+05	1.41E+03		
124	N-Nitroso-N-methylurea	684935							
125	N-Nitrosodimethylamine	62759				3.10E+05	3.10E+03	3.57E+09	3.57E+07
126	N-Nitrosomorpholine	59892				8.96E+02	8.96E+00		
127	Parathion	56382						1.60E+04	1.60E+04
128	Pentachloronitrobenzene	82688				1.28E+02	1.28E+00	5.05E+08	5.05E+06
129	Pentachlorophenol	87865				1.37E+01	1.37E-01	2.49E+08	2.49E+06
130	Phenol	108952	4.17E-05	1.03E-04	1.03E-04	1.37E+01	1.37E+01	2.73E+05	2.73E+05
131	p-Phenylenediamine	106503							
132	Phosgene	75445				1.33E+01	1.33E+01		
133	Phosphine	7803512				1.04E+01	1.04E+01		
134	Phosphorus (white)	7723140							
135	Phthalic anhydride	85449				3.99E+00	3.99E+00		
136	Polychlorinated biphenyls (PCBs)	1336363		5.50E-02	5.50E-04	2.89E+00	2.89E-02	1.55E+12	1.55E+10
137	1,3-Propane sultone	1120714				4.97E-01	4.97E-03		
138	beta-Propiolactone	57578							
139	Propionaldehyde	123386							
140	Baygon (propoxur)	114261						3.69E+00	3.69E+00
141	1,2-Dichloropropane (propylene dichloride)	78875	7.22E-06	6.08E+00	8.00E-02	1.03E+04	1.36E+02		
142	Propylene oxide	75569				1.11E+04	1.11E+02		
143	1,2-Propylenimine (2-methyl aziridine)	75558							
144	Quinoline	91225				7.88E+04	7.88E+02		
145	Quinone	106514							
146	Styrene	100425	1.25E-04	7.10E-04	7.10E-04	3.95E+01	3.95E+01		
147	Styrene oxide	96093				2.92E-02	2.92E-02		
148	2,3,7,8-TCDD (dioxin)	1746016				8.10E+04	8.10E+02	2.12E+12	2.12E+10
149	1,1,2,2-Tetrachloroethane	79345	6.38E-06	4.87E+00	4.87E-02	1.27E+04	1.27E+02		
150	Tetrachloroethylene (PCE)	127184	5.10E-04	8.26E+00	8.26E-02	6.11E+05	6.11E+03	2.58E+11	2.58E+09
151	Titanium tetrachloride	7550450				5.04E+01	5.04E+01		
152	Toluene	108883	5.50E-04	2.18E-02	2.18E-02	2.00E+03	2.00E+03		
153	Toluene-2,4-diamine	95807							
154	2,4/2,6-Toluene diisocyanate mixture	26471625				7.76E+02	7.76E+02		
155	2-Methylaniline (o-toluidine)	95534				4.41E+02	4.41E+00		
156	Toxaphene	8001352							
157	1,2,4-Trichlorobenzene	120821		6.50E-04	6.50E-04	1.61E+01	1.61E+01	6.75E+08	6.75E+08
158	1,1,2-Trichloroethane	79005	1.00E-05	1.76E+00	1.76E-02	7.90E+03	7.90E+01	1.20E+08	1.20E+06
159	Trichloroethylene (TCE)	79016	3.70E-06	1.38E+00	1.38E-02	1.33E+05	1.33E+03		
160	2,4,5-Trichlorophenol	95954						7.46E+03	7.46E+03
161	2,4,6-Trichlorophenol	88062				1.44E+00	1.44E-02		
162	Triethylamine	121448				7.86E+01	7.86E+01		
163	Trifluralin	1582098				2.00E+01	2.00E-01	2.92E+08	5.05E+06
164	2,2,4-Trimethylpentane	540841							

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HAP No.	Contaminant	CAS #	Index 1: Measured Max./ Acute RBC	Index 2: Measured Avg./ Chronic RBC		Index 3: NTI Urban Emissions/ Chronic RBC		Index 4: NTI * BCF/ Chronic RBD	
				Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
165	Vinyl acetate	108054				1.62E+01	1.62E+01		
166	Vinyl bromide	593602				4.09E+01	4.40E-01		
167	Vinyl chloride	75014	1.00E-05	4.21E+01	4.21E-01	2.08E+05	2.08E+03	1.63E+10	1.63E+08
168	1,1-Dichloroethylene	75354		5.50E+00	5.50E-02	1.04E+04	1.04E+02		
169	Xylene (mixed)	1330207	5.50E-03	2.56E-02	2.56E-02	1.02E+03	1.02E+03		
170	o-Xylene	95476	2.03E-05						
171	m-Xylene	108383	2.28E-05						
172	p-Xylene	106423	1.15E-05						
173	Antimony and compounds	7440360	7.00E-07	1.10E-02	1.10E-02	5.41E+02	5.41E+02	8.55E+05	8.55E+05
173	-Antimony pentafluoride	7783702							
173	-Antimony pentoxide	1314609							
173	-Antimony potassium tartrate	304610							
173	-Antimony tetroxide	1332816							
173	-Antimony trioxide	1309644				8.85E+01	8.85E+01		
174	Arsenic and compounds	7440382	3.25E-03	4.73E+00	4.73E-02	8.51E+05	8.51E+03	1.19E+09	1.19E+07
174	-Arsine	7784421							
174	-Arsenic oxide	1327533							
174	-Arsenic pentoxide	1303282							
175	Beryllium and compounds	7440417				1.99E+04	4.14E+02	7.87E+04	7.87E+04
176	Cadmium and compounds	7440439	2.78E-07	4.50E+00	2.50E-01	2.99E+05	1.66E+04	4.65E+11	4.65E+09
176	-Cadmium oxide	1306190							
177	Chromium III and compounds	16065831							
177	Chromium VI and compounds	18540299	1.33E-05	6.96E+01	6.96E-01	3.18E+06	3.18E+04		
177	-Chromic chloride	10025737							
178	Cobalt and compounds	7440484	1.50E-06						
178	-Cobalt carbonyl	10210681							
179	Coke Oven Emissions	8007452				9.76E+05	9.76E+03	3.85E+05	3.85E+05
180	Cyanide compounds	57125							
180	-Barium cyanide	542621							
180	-Calcium cyanide	592018							
180	-Chlorine cyanide	506774							
180	-Copper cyanide	544923							
180	-Cyanazine	21725462							
180	-Cyanogen	460195							
180	-Cyanogen bromide	506683							
180	-Cyanogen chloride	506774							
180	-Free cyanide	57125							
180	-Hydrogen cyanide	74908							
180	-Potassium cyanide	151508							
180	-Potassium silver cyanide	506616							
180	-Silver cyanide	506649							
180	-Sodium cyanide	143339							

Table 4. Raw ranking index scores, by HAP.

HAP No.	Contaminant	CAS #	Index 1: Measured Max./ Acute RBC	Index 2: Measured Avg./ Chronic RBC		Index 3: NTI Urban Emissions/ Chronic RBC		Index 4: NTI * BCF/ Chronic RBD	
				Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
180	-Thiocyanate	THIOCYA							
180	-Zinc cyanide	557211							
181	Glycol ethers					2.84E+03	2.84E+03		
181	-Diethylene glycol, monobutyl ether	112345							
181	-Diethylene glycol, monoethyl ether	111900							
181	-2-Ethoxyethanol (ethylene glycol ethyl e	110805							
181	-Ethylene glycol monobutyl ether	111762							
181	-2-Methoxyethanol acetate	110496							
181	-2-Methoxyethanol	109864							
182	Lead and lead compounds	7439921	1.80E-06	7.56E-02	4.20E-03	3.28E+04	1.82E+03	3.95E+10	3.95E+08
182	-Tetramethyl lead	75741							
182	-Tetraethyl lead	78002							
183	Manganese and compounds	7439965	1.40E-07	6.20E-02	6.20E-02	3.86E+04	3.86E+04		
183	-Methylcyclopentadienyl manganese	12108133							
184	Mercury and compounds	7439976	5.50E-04	3.33E-03	3.33E-03	5.07E+02	5.07E+02	1.04E+13	1.04E+13
184	-Mercury (elemental)	7439976							
184	-Mercuric chloride	7487947							
184	-Mercury (methyl)	22967926							
186	Nickel and compounds	7440020	3.30E-04	1.32E-01	5.50E-03	1.34E+05	5.59E+03	1.02E+09	1.02E+07
186	-Nickel refinery dust	NI_DUST							
186	-Nickel subsulfide	12035722							
187	Polycyclic Organic Matter	POM							
187	Carcinogenic PAHs: 7-PAH			7.60E+02	7.60E+00	1.60E+02	1.60E+00	9.98E+11	9.98E+09
187	-Acenaphthene	83329						6.74E+01	6.74E+01
187	-Anthracene	120127						4.46E+04	4.46E+04
187	-Benz[a]anthracene	56553							
187	-Benzo[b]fluoranthene	205992							
187	-Benzo[k]fluoranthene	207089							
187	-Benzo[a]pyrene	50328							
187	-Carbazole	86748							
187	-Chrysene	218019							
187	-Dibenz[a,h]acridine	226368							
187	-Dibenz[a,j]acridine	224420				3.82E-03	3.82E-05	7.75E+05	7.75E+03
187	-Dibenz[a,h]anthracene	53703							
187	-7H-Dibenzo[c,g]carbazole	194592							
187	-Dibenzo[a,e]pyrene	192654				1.66E+00	1.66E-02	1.25E+08	1.25E+06
187	-Dibenzo[a,i]pyrene	189559							
187	-Dibenzo[a,l]pyrene	191300							
187	-7,12-Dimethylbenz[a]anthracene	57976							
187	-1,6-Dinitropyrene	42397648							
187	-1,8-Dinitropyrene	42397659							
187	-Fluoranthene	206440						2.58E+03	2.58E+03

Table 4. Raw ranking index scores, by HAP.

HAP No.	Contaminant	CAS #	Index 1: Measured Max./ Acute RBC	Index 2: Measured Avg./ Chronic RBC		Index 3: NTI Urban Emissions/ Chronic RBC		Index 4: NTI * BCF/ Chronic RBD	
				Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
187	-Fluorene	86737						6.44E+02	6.44E+02
187	-Hexachlorodibenzo-p-dioxin mixture	19408743				1.59E+02	1.59E+00		
187	-Indeno[1,2,3-cd]pyrene	193395							
187	-3-Methylcholanthrene	56495							
187	-5-Methylchrysene	3697243							
187	-2-Methylnaphthalene	91576							
187	-5-Nitroacenaphthene	602879							
187	-6-Nitrochrysene	2043937							
187	-2-Nitrofluorene	607578							
187	-2-Nitrofluorene	607578							
187	-1-Nitropyrene	5522430							
187	-4-Nitropyrene	57835924							
187	-Pyrene	129000						5.17E+02	5.17E+02
189	Selenium	7782492						9.10E+06	9.10E+06
189	-Hydrogen selenide	2148909							
189	-Selenious Acid	7783008							
189	-Sodium selenate	13410010							
189	-Sodium selenite	10102188							

Ranking Index Algorithms:

Index 1 = 95th %ile measured concentration / RBC for acute effects
Index 2 = Mean measured concentration / RBC for chronic effects (cancer or non-cancer)
Index 3 = Tons per year emitted in urban areas / RBC for chronic effects (cancer or non-cancer)
Index 4 = Tons per year emitted in urban areas X bioconcentration factor / risk-based dose for chronic effects (cancer or non-cancer)

Table 5. Adjusted ranking index scores by HAP (normalized to a scale of 1-100), average index scores, and hazard ranks.

HAP No.	Contaminant	CAS #	Index 1: Ambient 95th %ile / Acute RBC	Index 2: Ambient Average / Chronic RBC		Index 3: NTI Urban Emissions / Chronic RBC		Index 4: NTI Urban Emissions * BCF / Chronic RBC		Mean Index	Overall OAQPS Rank
				Case 1	Case 2	Case 1	Case 2	Case 1	Case 2		
1	Acetaldehyde	75070	5.88E-02	7.23E-01	3.65E+00	1.44E+00	5.76E-01			1.29E+00	19
2	Acetamide	60355				4.00E-06	3.17E-07			2.16E-06	139
3	Acetonitrile	75058				1.48E-04	1.17E-03	4.54E-06	4.54E-06	3.32E-04	118
4	Acetophenone	98862									
5	2-Acetylaminofluorene	53963									
6	Acrolein	107028	1.00E+02	3.42E-01	3.42E+01	1.26E+01	1.00E+02	1.86E-03	1.86E-03	3.53E+01	1
7	Acrylamide	79061				3.59E-01	2.85E-02	1.42E-03	1.42E-05	9.72E-02	47
8	Acrylic acid	79107				4.13E-03	3.28E-02	3.05E-08	3.05E-08	9.24E-03	74
9	Acrylonitrile	107131				1.26E+00	1.00E-01			6.80E-01	23
10	Allyl chloride	107051				5.25E-03	6.95E-03			6.10E-03	79
11	4-Aminobiphenyl	92671									
12	Aniline	62533				5.06E-03	2.51E-02	5.41E-05	5.41E-07	7.57E-03	76
13	o-Anisidine	90040									
14	Asbestos*	1332214									
15	Benzene	71432	2.38E+00	3.38E+00	3.38E+00	1.65E+01	1.31E+00	5.57E-01	5.57E-03	3.94E+00	10
16	Benzidine	92875				1.67E-01	1.33E-02	1.43E-03	1.43E-05	4.55E-02	57
17	Benzotrichloride	98077				1.91E-01	1.52E-02			1.03E-01	45
18	Benzyl chloride	100447				2.48E-02	1.97E-03			1.34E-02	70
19	1,1-Biphenyl	92524									
20	Bis(2-ethylhexyl)phthalate (DEHP)	117817		1.83E-03	7.63E-03	1.14E-02	3.77E-03	6.61E-02	6.61E-04	1.52E-02	68
21	Bis(chloromethyl)ether	542881				2.07E-01	1.64E-02	2.71E-03	2.71E-05	5.64E-02	54
22	Bromoform (tribromomethane)	75252	2.14E-06	7.23E-04	7.23E-04	6.59E-04	5.24E-05			4.32E-04	113
23	1,3-Butadiene	106990	1.50E-02	3.39E+01	3.39E+01	1.00E+02	7.94E+00			3.51E+01	2
24	Calcium cyanamide	156627									
25	Caprolactam	105602									
26	Captan	133062				1.56E-05	1.24E-06	8.20E-07	8.20E-09	4.41E-06	136
27	Carbaryl	63252									
28	Carbon disulfide	75150				8.96E-04	7.11E-03			4.01E-03	84
29	Carbon tetrachloride	56235	5.65E-02	1.78E+00	1.78E+00	4.13E-01	3.28E-02	1.26E-01	1.39E-03	5.97E-01	25
30	Carbonyl sulfide	463581									
31	Catechol	120809									
32	Chloramben	133904									
33	Chlordane	57749				3.94E-05	4.48E-06	3.53E-03	3.53E-05	9.01E-04	102
34	Chlorine	7782505				2.99E-02	2.37E-01			1.34E-01	40
35	Chloroacetic acid	79118						4.61E-07	4.61E-07	4.61E-07	143
36	2-Chloroacetophenone	532274				5.20E-04	4.13E-03			2.32E-03	92
37	Chlorobenzene	108907	4.25E-04	1.91E-03	1.91E-01	3.68E-03	2.92E-02			4.52E-02	58
38	Chlorobenzilate	510156				1.28E-03	1.02E-04	2.24E-03	2.24E-05	9.12E-04	101
39	Chloroform	67663	4.82E-01	1.18E+00	1.18E+00	2.52E+00	2.00E-01	4.69E-03	7.69E-05	7.95E-01	20

Table 5. Adjusted ranking index scores by HAP (normalized to a scale of 1-100), average index scores, and hazard ranks.

HAP No.	Contaminant	CAS #	Index 1: Ambient 95th %ile / Acute RBC	Index 2: Ambient Average / Chronic RBC Case 1	Index 2: Case 2	Index 3: NTI Urban Emissions / Chronic RBC Case 1	Index 3: Case 2	Index 4: NTI Urban Emissions * BCF / Chronic RBC Case 1	Index 4: Case 2	Mean Index	Overall OAQPS Rank
40	Chloromethyl methyl ether	107302									
41	2-Chloro-1,3-butadiene (chloroprene)	126998	2.57E-03	7.89E-03	7.89E-01	1.20E-03	9.52E-03			1.62E-01	38
42	Cresols/cresylic acid (isomers and mixture)	1319773				1.28E-02	1.02E-01			5.75E-02	53
43	2-Methylphenol (o-cresol)	95487									
44	3-Methylphenol (m-cresol)	108394									
45	4-Methylphenol (p-cresol)	106445									
46	Cumene	98828	3.69E-04	8.55E-05	8.55E-03	1.50E-04	1.19E-03			2.07E-03	93
47	2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757						7.65E-06	7.65E-06	7.65E-06	133
48	DDE	72559		3.06E-02	3.06E-02					3.06E-02	62
49	Diazomethane	334883									
50	Dibenzofuran	132649									
51	1,2-Dibromo-3-chloropropane	96128				4.63E-04	3.68E-03	1.32E-03	1.32E-05	1.37E-03	99
52	Dibutyl phthalate	84742	8.82E-06					2.64E-05	2.64E-05	2.06E-05	132
53	1,4-Dichlorobenzene	106467	1.36E-02	2.96E-04	2.96E-02	4.40E-05	3.49E-04	1.11E-01	1.11E-03	2.22E-02	66
54	3,3'-Dichlorobenzidine	91941				1.09E-03	8.68E-05			5.89E-04	110
55	Bis(2-chloroethyl)ether	111444				1.01E-02	7.99E-04			5.43E-03	80
56	1,3-Dichloropropene	542756		4.48E-01	4.48E-01	5.10E+00	4.05E-01			1.60E+00	15
57	Dichlorvos	62737				7.81E-05	1.49E-05			4.65E-05	131
58	Diethanolamine	111422				5.29E-05	4.20E-04			2.37E-04	120
59	N-N-Dimethylaniline	121697									
60	Diethyl sulfate	64675									
61	3,3'-Dimethoxybenzidine	119904				2.17E-05	1.73E-06	4.35E-07	4.35E-09	5.97E-06	135
62	p-Dimethylaminoazobenzene	60117				2.48E-03	1.97E-04	1.02E-04	1.02E-06	6.95E-04	107
63	3,3'-Dimethylbenzidine	119937				5.09E-03	4.04E-04	6.06E-04	6.06E-06	1.53E-03	97
64	Dimethyl carbamoyl chloride	79447									
65	N,N-Dimethylformamide	68122				8.45E-04	6.71E-03			3.78E-03	88
66	1,1-Dimethylhydrazine	57147									
67	Dimethyl phthalate	131113									
68	Dimethyl sulfate	77781									
69	4,6-Dinitro-2-methylphenol	534521									
70	2,4-Dinitrophenol	51285						1.30E-07	1.30E-07	1.30E-07	146
71	Dinitrotoluene mixture	25321146									
71	2,4-Dinitrotoluene	121142				3.35E-04	2.66E-05			1.81E-04	123
72	1,4-Dioxane	123911				4.53E-02	3.60E-03			2.45E-02	65
73	1,2-Diphenylhydrazine	122667									
74	Epichlorohydrin	106898				3.20E-03	2.12E-02	9.73E-05	4.92E-06	6.12E-03	78
75	1,2-Epoxybutane	106887				1.86E-05	1.48E-04			8.31E-05	128
76	Ethyl acrylate	140885				1.74E-02	1.38E-03			9.39E-03	72
77	Ethylbenzene	100414	2.15E-03	1.71E-04	1.71E-02	6.42E-04	5.10E-03			5.03E-03	82

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Table 5. Adjusted ranking index scores by HAP (normalized to a scale of 1-100), average index scores, and hazard ranks.

HAP No.	Contaminant	CAS #	Index 1: Ambient 95th %ile / Acute RBC	Index 2: Ambient Average / Chronic RBC Case 1	Index 2: Case 2	Index 3: NTI Urban Emissions / Chronic RBC Case 1	Index 3: Case 2	Index 4: NTI Urban Emissions * BCF / Chronic RBC Case 1	Index 4: Case 2	Mean Index	Overall OAQPS Rank
78	Ethyl carbamate (urethane)	51796				1.92E-02	1.52E-03			1.04E-02	71
79	Chloroethane (ethyl chloride)	75003	2.02E-04	3.55E-06	3.55E-04	1.48E-06	1.17E-05			1.15E-04	125
80	1,2-Dibromoethane	106934	1.34E-03	1.24E+01	2.83E+01	5.55E-02	1.00E-02	1.81E-01	1.81E-03	5.85E+00	7
81	1,2-Dichloroethane (EDC)	107062	5.29E-02	4.44E+00	4.44E+00	5.94E-01	4.72E-02	4.84E-03	4.84E-05	1.37E+00	18
82	Ethylene glycol	107211				1.97E-04	1.56E-03			8.80E-04	103
83	Ethylene imine (aziridine)	151564									
84	Ethylene oxide	75218				1.78E+00	1.41E-01	6.57E-02	6.57E-04	4.97E-01	26
85	Ethylene thiourea (ETU)	96457				1.96E-04	3.99E-05	2.11E-05	2.11E-07	6.42E-05	130
86	1,1-Dichloroethane	75343	4.31E-05	2.00E-02	2.00E-02	5.09E-02	4.04E-03	1.01E-03	1.01E-05	1.37E-02	69
87	Formaldehyde	50000	3.92E+00	4.79E+00	9.95E+00	2.20E+01	3.63E+00			8.86E+00	6
88	Heptachlor	76448	1.68E-04	4.10E-01	4.10E-01	3.12E-04	2.48E-05	2.51E-02	2.51E-04	1.21E-01	41
89	Hexachlorobenzene	118741		1.45E-01	1.45E-01	7.88E-03	6.26E-04	5.96E-01	5.96E-03	1.50E-01	39
90	Hexachlorobutadiene	87683	1.69E-03	2.86E-01	2.86E-01	2.40E-03	1.91E-04	6.88E-02	4.41E-03	9.29E-02	50
91	Hexachlorocyclopentadiene	77474		9.96E-04	9.96E-02	9.52E-05	7.57E-04	2.10E-06	2.10E-06	1.69E-02	67
92	Hexachloroethane	67721	1.01E-05	1.26E-03	1.26E-03	8.45E-04	6.72E-05	2.44E-03	1.75E-04	8.67E-04	104
93	Hexamethylene-1,6-diisocyanate	822060				1.16E-04	9.19E-04			5.17E-04	111
94	Hexamethylphosphoramide	680319									
95	n-Hexane	110543	3.20E-03	1.51E-03	1.51E-01	5.09E-03	4.04E-02			4.03E-02	59
96	Hydrazine, hydrazine sulfate	302012				5.03E-01	4.00E-02			2.72E-01	35
97	Hydrogen chloride	7647010	2.47E-01	1.25E-02	1.25E+00	7.78E-01	6.18E+00			1.69E+00	14
98	Hydrogen fluoride	7664393	1.01E-01	2.41E-04	2.41E-02	7.98E-03	6.34E-02			3.94E-02	60
99	Hydroquinone	123319									
100	Isophorone	78591				6.88E-04	5.46E-05			3.71E-04	116
101	alpha-Hexachlorocyclohexane (a-HCH)	319846									
101	beta-Hexachlorocyclohexane (b-HCH)	319857									
101	gamma-Hexachlorocyclohexane (g-HCH,Lindane)	58899									
101	technical Hexachlorocyclohexane (HCH)	608731									
102	Maleic anhydride	108316				7.96E-03	6.32E-02			3.56E-02	61
103	Methanol	67561				2.16E-04	1.71E-03			9.65E-04	100
104	Methoxychlor	72435						7.54E-07	7.54E-07	7.54E-07	142
105	Bromomethane (methyl bromide)	74839	2.29E-02	2.47E-02	2.47E+00	4.12E-02	3.27E-01	2.85E-04	2.85E-04	4.13E-01	27
106	Chloromethane (methyl chloride)	74873	1.16E-03	2.84E-01	2.84E-01	8.00E-02	6.36E-03	2.13E-03	2.13E-05	9.40E-02	48
107	1,1,1-Trichloroethane	71556	4.03E-01	4.34E-04	4.34E-02	1.94E-03	1.54E-02			9.29E-02	49
108	Methyl ethyl ketone	78933	1.24E-02	1.97E-04	1.97E-02	1.56E-03	1.24E-02			9.27E-03	73
109	Methyl hydrazine	60344									
110	Methyl iodide	74884									
111	Methyl isobutyl ketone	108101		3.78E-03	3.78E-01	3.30E-03	2.62E-02			1.03E-01	46
112	Methyl isocyanate	624839				4.08E-05	3.24E-04			1.83E-04	122
113	Methyl methacrylate	80626				1.72E-05	1.36E-04			7.68E-05	129

Table 5. Adjusted ranking index scores by HAP (normalized to a scale of 1-100), average index scores, and hazard ranks.

HAP			Index 1:	Index 2:		Index 3:		Index 4:			
			Ambient 95th %ile /	Ambient Average / Chronic RBC		NTI Urban Emissions / Chronic RBC		NTI Urban Emissions * BCF / Chronic RBC		Mean	Overall OAQPS
No.	Contaminant	CAS #	Acute RBC	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Index	Rank
114	Methyl tertbutyl ether (MTBE)	1634044	3.92E-01	2.19E-04	2.19E-02	2.94E-05	2.33E-04			8.29E-02	51
115	4,4'-Methylene bis(2-chloroaniline)	101144				1.89E-04	1.50E-05	1.28E-04	1.28E-06	8.33E-05	127
116	Methylene chloride	75092	2.88E-01	1.92E-01	1.92E-01	3.53E-01	2.81E-02	1.07E-01	1.07E-03	1.66E-01	37
117	4,4'-Methylenediphenyl diisocyanate	101688				1.55E-03	1.23E-02			6.91E-03	77
118	4,4'-Methylenedianiline	101779				1.38E-02	1.10E-03	3.88E-04	3.88E-06	3.83E-03	86
119	Naphthalene	91203	3.62E-03	2.76E-02	2.76E+00	5.63E-03	4.47E-02	4.20E-04	4.20E-04	4.06E-01	28
120	Nitrobenzene	98953				1.78E-04	1.41E-03	1.26E-05	1.26E-05	4.05E-04	114
121	4-Nitrobiphenyl	92933									
122	4-Nitrophenol	100027									
123	2-Nitropropane	79469				1.17E+00	9.26E-02			6.29E-01	24
124	N-Nitroso-N-methylurea	684935									
125	N-Nitrosodimethylamine	62759				2.57E+00	2.04E-01	3.45E-02	3.45E-04	7.01E-01	22
126	N-Nitrosomorpholine	59892				7.41E-03	5.89E-04			4.00E-03	85
127	Parathion	56382						1.55E-07	1.55E-07	1.55E-07	145
128	Pentachloronitrobenzene	82688				1.06E-03	8.43E-05	4.88E-03	4.88E-05	1.52E-03	98
129	Pentachlorophenol	87865				1.13E-04	8.98E-06	2.41E-03	2.41E-05	6.39E-04	108
130	Phenol	108952	9.80E-03	1.36E-05	1.36E-03	1.13E-04	8.99E-04	2.63E-06	2.63E-06	1.74E-03	96
131	p-Phenylenediamine	106503									
132	Phosgene	75445				1.10E-04	8.73E-04			4.91E-04	112
133	Phosphine	7803512				8.65E-05	6.87E-04			3.87E-04	115
134	Phosphorus (white)	7723140									
135	Phthalic anhydride	85449				3.31E-05	2.63E-04			1.48E-04	124
136	Polychlorinated biphenyls (PCBs)	1336363		7.23E-03	7.23E-03	2.39E-05	1.90E-06	1.50E+01	1.50E-01	2.53E+00	11
137	1,3-Propane sultone	1120714				4.12E-06	3.27E-07			2.22E-06	138
138	beta-Propiolactone	57578									
139	Propionaldehyde	123386									
140	Baygon (propoxur)	114261						3.56E-11	3.56E-11	3.56E-11	152
141	1,2-Dichloropropane (propylene dichloride)	78875	1.70E-03	8.00E-01	1.05E+00	8.53E-02	8.92E-03			3.90E-01	29
142	Propylene oxide	75569				9.17E-02	7.28E-03			4.95E-02	55
143	1,2-Propylenimine (2-methyl aziridine)	75558									
144	Quinoline	91225				6.52E-01	5.18E-02			3.52E-01	31
145	Quinone	106514									
146	Styrene	100425	2.94E-02	9.34E-05	9.34E-03	3.27E-04	2.60E-03			8.35E-03	75
147	Styrene oxide	96093				2.42E-07	1.92E-06			1.08E-06	141
148	2,3,7,8-TCDD (dioxin)	1746016				6.71E-01	5.33E-02	2.05E+01	2.05E-01	5.35E+00	8
149	1,1,2,2-Tetrachloroethane	79345	1.50E-03	6.41E-01	6.41E-01	1.05E-01	8.33E-03			2.79E-01	34
150	Tetrachloroethylene (PCE)	127184	1.20E-01	1.09E+00	1.09E+00	5.05E+00	4.01E-01	2.50E+00	2.50E-02	1.47E+00	16
151	Titanium tetrachloride	7550450				4.17E-04	3.32E-03			1.87E-03	95
152	Toluene	108883	1.29E-01	2.86E-03	2.86E-01	1.66E-02	1.32E-01			1.13E-01	43

Table 5. Adjusted ranking index scores by HAP (normalized to a scale of 1-100), average index scores, and hazard ranks.

HAP No.	Contaminant	CAS #	Index 1: Ambient 95th %ile / Acute RBC	Index 2: Ambient Average / Chronic RBC Case 1	Index 2: Case 2	Index 3: NTI Urban Emissions / Chronic RBC Case 1	Index 3: Case 2	Index 4: NTI Urban Emissions * BCF / Chronic RBC Case 1	Index 4: Case 2	Mean Index	Overall OAQPS Rank
153	Toluene-2,4-diamine	95807				6.43E-03	5.11E-02			2.87E-02	63
154	2,4/2,6-Toluene diisocyanate mixture	26471625				3.65E-03	2.90E-04			1.97E-03	94
155	2-Methylaniline (o-toluidine)	95534									
156	Toxaphene	8001352									
157	1,2,4-Trichlorobenzene	120821		8.55E-05	8.55E-03	1.34E-04	1.06E-03	6.52E-03	6.52E-03	3.81E-03	87
158	1,1,2-Trichloroethane	79005	2.35E-03	2.31E-01	2.31E-01	6.54E-02	5.19E-03	1.16E-03	1.16E-05	7.67E-02	52
159	Trichloroethylene (TCE)	79016	8.71E-04	1.81E-01	1.81E-01	1.10E+00	8.74E-02			3.10E-01	33
160	2,4,5-Trichlorophenol	95954						7.20E-08	7.20E-08	7.20E-08	147
161	2,4,6-Trichlorophenol	88062				1.20E-05	9.50E-07			6.45E-06	134
162	Triethylamine	121448				6.51E-04	5.17E-03			2.91E-03	90
163	Trifluralin	1582098				1.65E-04	1.31E-05	2.82E-03	4.88E-05	7.61E-04	105
164	2,2,4-Trimethylpentane	540841									
165	Vinyl acetate	108054				1.34E-04	1.06E-03			5.99E-04	109
166	Vinyl bromide	593602				3.39E-04	2.89E-05			1.84E-04	121
167	Vinyl chloride	75014	2.35E-03	5.54E+00	5.54E+00	1.72E+00	1.37E-01	1.58E-01	1.58E-03	1.87E+00	12
168	1,1-Dichloroethylene	75354		7.23E-01	7.23E-01	8.59E-02	6.82E-03			3.85E-01	30
169	Xylene (mixed)	1330207	1.29E+00	3.36E-03	3.36E-01	8.42E-03	6.69E-02			3.42E-01	32
170	o-Xylene	95476	4.77E-03							4.77E-03	83
171	m-Xylene	108383	5.37E-03							5.37E-03	81
172	p-Xylene	106423	2.71E-03							2.71E-03	91
173	Antimony and compounds	7440360	1.65E-04	1.45E-03	1.45E-01	4.48E-03	3.56E-02	8.26E-06	8.26E-06	2.66E-02	64
173	-Antimony pentafluoride	7783702									
173	-Antimony pentoxide	1314609									
173	-Antimony potassium tartrate	304610									
173	-Antimony tetroxide	1332816									
173	-Antimony trioxide	1309644				7.33E-04	5.82E-03			3.28E-03	89
174	Arsenic and compounds	7440382	7.65E-01	6.22E-01	6.22E-01	7.05E+00	5.60E-01	1.15E-02	1.15E-04	1.38E+00	17
174	-Arsine	7784421									
174	-Arsenic oxide	1327533									
174	-Arsenic pentoxide	1303282									
175	Beryllium and compounds	7440417				1.65E-01	2.72E-02	7.60E-07	7.60E-07	4.80E-02	56
176	Cadmium and compounds	7440439	6.54E-05	5.92E-01	3.29E+00	2.47E+00	1.09E+00	4.49E+00	4.49E-02	1.71E+00	13
176	-Cadmium oxide	1306190									
177	Chromium III and compounds	16065831									
177	Chromium VI and compounds	18540299	3.14E-03	9.15E+00	9.15E+00	2.63E+01	2.09E+00			9.35E+00	5
177	-Chromic chloride	10025737									
178	Cobalt and compounds	7440484	3.53E-04							3.53E-04	117
178	-Cobalt carbonyl	10210681									
179	Coke Oven Emissions	8007452				8.08E+00	6.42E-01			4.36E+00	9

Table 5. Adjusted ranking index scores by HAP (normalized to a scale of 1-100), average index scores, and hazard ranks.

HAP No.	Contaminant	CAS #	Index 1: Ambient 95th %ile / Acute RBC	Index 2: Ambient Average / Chronic RBC Case 1	Index 2: Case 2	Index 3: NTI Urban Emissions / Chronic RBC Case 1	Index 3: Case 2	Index 4: NTI Urban Emissions * BCF / Chronic RBC Case 1	Index 4: Case 2	Mean Index	Overall OAQPS Rank
180	Cyanide compounds	57125						3.72E-06	3.72E-06	3.72E-06	137
180	-Barium cyanide	542621									
180	-Calcium cyanide	592018									
180	-Chlorine cyanide	506774									
180	-Copper cyanide	544923									
180	-Cyanazine	21725462									
180	-Cyanogen	460195									
180	-Cyanogen bromide	506683									
180	-Cyanogen chloride	506774									
180	-Free cyanide	57125									
180	-Hydrogen cyanide	74908									
180	-Potassium cyanide	151508									
180	-Potassium silver cyanide	506616									
180	-Silver cyanide	506649									
180	-Sodium cyanide	143339									
180	-Thiocyanate	THIOCYA									
180	-Zinc cyanide	557211									
181	Glycol ethers					2.35E-02	1.87E-01			1.05E-01	44
181	-Diethylene glycol, monobutyl ether	112345									
181	-Diethylene glycol, monoethyl ether	111900									
181	-2-Ethoxyethanol (ethylene glycol ethyl e	110805									
181	-Ethylene glycol monobutyl ether	111762									
181	-2-Methoxyethanol acetate	110496									
181	-2-Methoxyethanol	109864									
182	Lead and lead compounds	7439921	4.24E-04	9.94E-03	5.52E-02	2.72E-01	1.20E-01	3.82E-01	3.82E-03	1.20E-01	42
182	-Tetramethyl lead	75741									
182	-Tetraethyl lead	78002									
183	Manganese and compounds	7439965	3.29E-05	8.15E-03	8.15E-01	3.20E-01	2.54E+00			7.37E-01	21
183	-Methylcyclopentadienyl manganese	12108133									
184	Mercury and compounds	7439976	1.29E-01	4.38E-04	4.38E-02	4.20E-03	3.34E-02	1.00E+02	1.00E+02	2.86E+01	4
184	-Mercury (elemental)	7439976									
184	-Mercuric chloride	7487947									
184	-Mercury (methyl)	22967926									
186	Nickel and compounds	7440020	7.76E-02	1.74E-02	7.23E-02	1.11E+00	3.67E-01	9.82E-03	9.82E-05	2.36E-01	36
186	-Nickel refinery dust	NI_DUST									
186	-Nickel subsulfide	12035722									
187	Polycyclic Organic Matter	POM									
187	Carcinogenic PAHs: 7-PAH			1.00E+02	1.00E+02	1.33E-03	1.05E-04	9.64E+00	9.64E-02	3.50E+01	3
187	-Acenaphthene	83329						6.51E-10	6.51E-10	6.51E-10	151

Table 5. Adjusted ranking index scores by HAP (normalized to a scale of 1-100), average index scores, and hazard ranks.

HAP No.	Contaminant	CAS #	Index 1: Ambient 95th %ile / Acute RBC	Index 2: Ambient Average / Chronic RBC		Index 3: NTI Urban Emissions / Chronic RBC		Index 4: NTI Urban Emissions * BCF / Chronic RBC		Mean Index	Overall OAQPS Rank
				Case 1	Case 2	Case 1	Case 2	Case 1	Case 2		
187	-Anthracene	120127						4.31E-07	4.31E-07	4.31E-07	144
187	-Benz[a]anthracene	56553									
187	-Benzo[b]fluoranthene	205992									
187	-Benzo[k]fluoranthene	207089									
187	-Benzo[a]pyrene	50328									
187	-Carbazole	86748									
187	-Chrysene	218019									
187	-Dibenz[a,h]acridine	226368									
187	-Dibenz[a,j]acridine	224420				3.16E-08	2.51E-09	7.49E-06	7.49E-08	1.90E-06	140
187	-Dibenz[a,h]anthracene	53703									
187	-7H-Dibenzo[c,g]carbazole	194592									
187	-Dibenzo[a,e]pyrene	192654				1.37E-05	1.09E-06	1.21E-03	1.21E-05	3.09E-04	119
187	-Dibenzo[a,i]pyrene	189559									
187	-Dibenzo[a,l]pyrene	191300									
187	-7,12-Dimethylbenz[a]anthracene	57976									
187	-1,6-Dinitropyrene	42397648									
187	-1,8-Dinitropyrene	42397659									
187	-Fluoranthene	206440						2.49E-08	2.49E-08	2.49E-08	148
187	-Fluorene	86737						6.22E-09	6.22E-09	6.22E-09	149
187	-Hexachlorodibenzo-p-dioxin mixture	19408743				1.31E-03	1.04E-04			7.09E-04	106
187	-Indeno[1,2,3-cd]pyrene	193395									
187	-3-Methylcholanthrene	56495									
187	-5-Methylchrysene	3697243									
187	-2-Methylnaphthalene	91576									
187	-5-Nitroacenaphthene	602879									
187	-6-Nitrochrysene	2043937									
187	-2-Nitrofluorene	607578									
187	-2-Nitrofluorene	607578									
187	-1-Nitropyrene	5522430									
187	-4-Nitropyrene	57835924									
187	-Pyrene	129000						5.00E-09	5.00E-09	5.00E-09	150
189	Selenium	7782492						8.79E-05	8.79E-05	8.79E-05	126
189	-Hydrogen selenide	2148909									
189	-Selenious Acid	7783008									
189	-Sodium selenate	13410010									
189	-Sodium selenite	10102188									

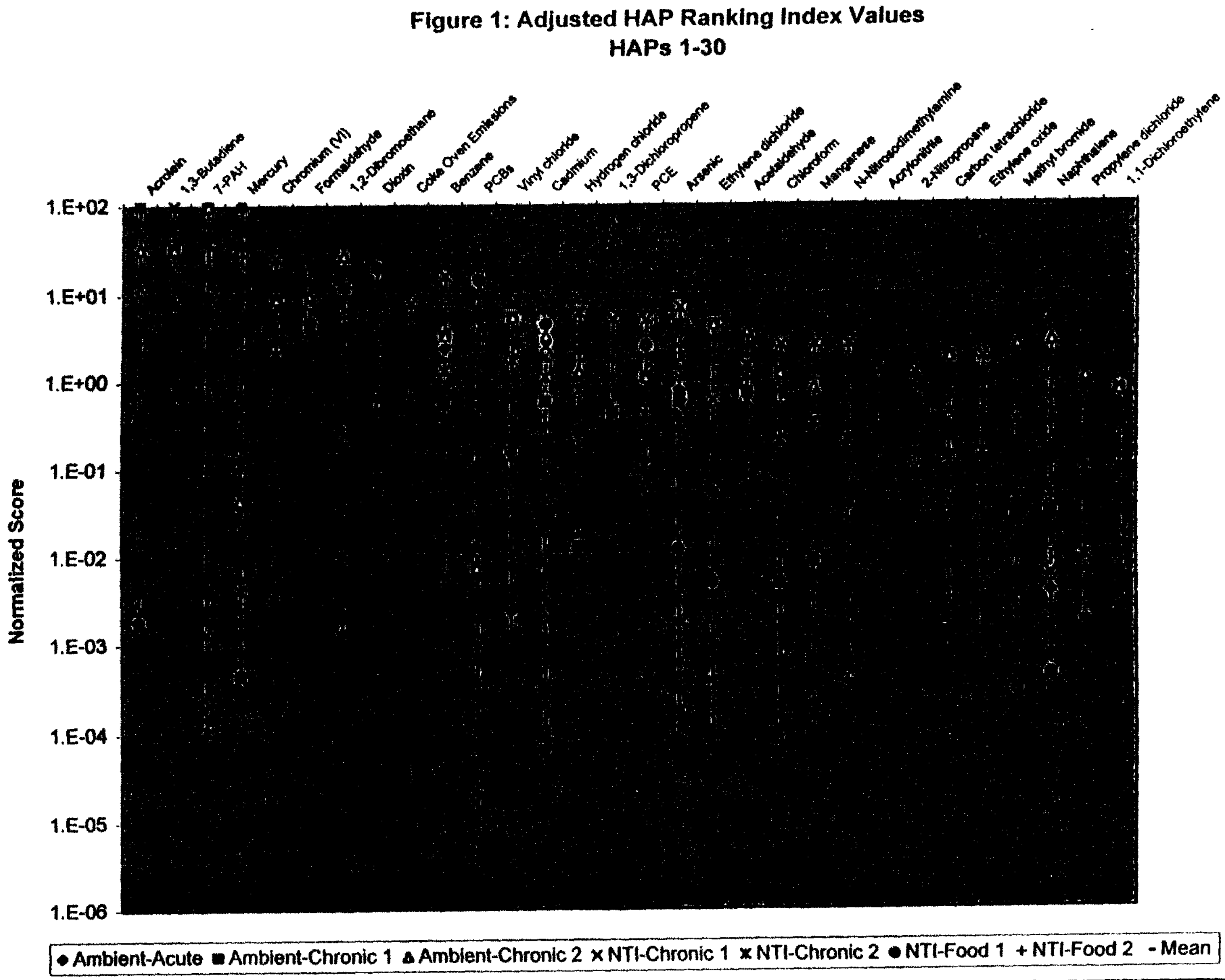
Figure 1: Adjusted HAP Ranking Index Values
HAPs 1-30
Acrolein
1,3-Butadiene
7-PAH
Mercury
Chromium (VI)
Formaldehyde
1,2-Dibromoethane
Dioxin
Coke Oven Emissions
Benzene
PCBs
Vinyl chloride
Cadmium
Hydrogen chloride
1,3-Dichloropropene
PCE
Arsenic
Ethylene dichloride
Acetaldehyde
Chloroform
Manganese
N-Nitrosodimethylamine
Acrylonitrile
2-Nitropropane
Carbon tetrachloride
Ethylene oxide
Methyl bromide
Naphthalene
Propylene dichloride
1,1-Dichloroethylene
Normalized Score
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
Ambient-Acute
Ambient-Chronic 1
Ambient-Chronic 2
NTI-Chronic 1
NTI-Chronic 2
NTI-Food 1
NTI-Food 2
Mean

Figure 2. Adjusted HAP Ranking Index Values: HAPs 31-60

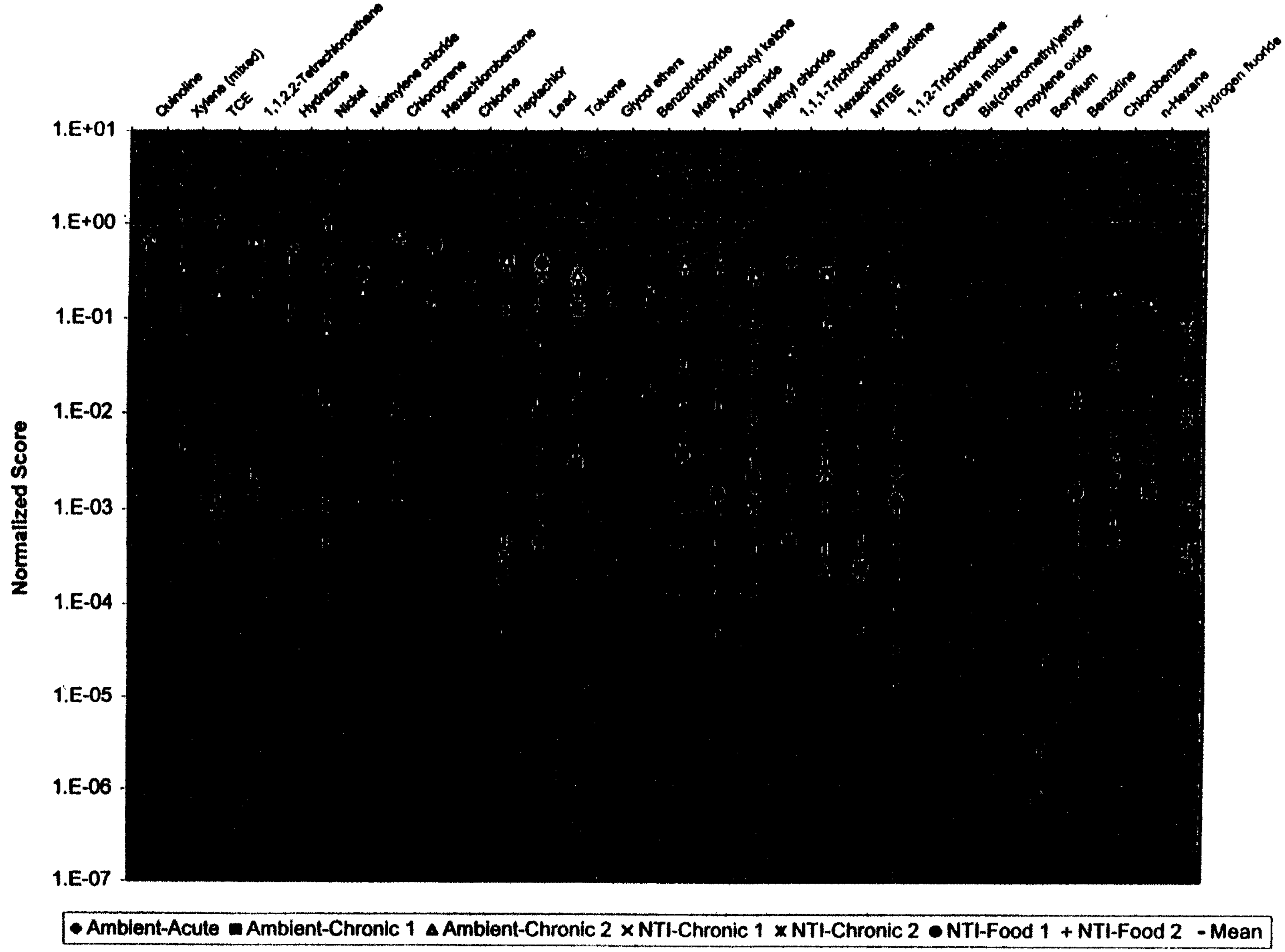

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Table 6. Results of the urban hazardous air pollutant selection process. Hazardous air pollutants to be used in selecting area sources for regulation under CAAA Section 112k are marked with a boldface ***X***. HAPs selected for the integrated urban air strategy, but not for area source selection, are marked with an ***O***. HAPs are sorted by 1- availability of publicly reviewed inventory; 2- number of analyses considering it a priority; and 3- ratio of area/total emissions.)

Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	QAQPS Ranking Analysis Top 40		Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
Tetrachloroethylene (PCE)	127184	X	X	X	16	81.4%	X	**X**	Identified by at least 2 analyses.
Acrolein	107028	X	X	X	1	66.9%	X	**X**	Identified by at least 2 analyses.
Ethylene oxide	75218	X	X	X	26	53.0%	X	**X**	Identified by at least 2 analyses.
Chromium VI and compounds	18540299	X	X	X	5	44.2%	X	**X**	Identified by at least 2 analyses.
Nickel and compounds	7440020	X	X	X	36	33.0%	X	**X**	Identified by at least 2 analyses.
Manganese and compounds	7439965	X	X	X	21	26.1%	X	**X**	Identified by at least 2 analyses.
Formaldehyde	50000	X	X	X	6	23.7%	X	**X**	Identified by at least 2 analyses.
Vinyl chloride	75014	X	X	X	12	20.2%	X	**X**	Identified by at least 2 analyses.
Trichloroethylene (TCE)	79016	X	X	X	33	19.3%	X	**X**	Identified by at least 2 analyses.
Cadmium and compounds	7440439	X	X	X	13	19.1%	X	**X**	Identified by at least 2 analyses.
Methylene chloride	75092	X	X	X	37	17.7%	X	**X**	Identified by at least 2 analyses.
Acrylonitrile	107131	X	X	X	23	16.8%	X	**X**	Identified by at least 2 analyses.
Arsenic and compounds	7440382	X	X	X	17	16.4%	X	**X**	Identified by at least 2 analyses.
1,3-Butadiene	106990	X	X	X	2	13.3%	X	**X**	Identified by at least 2 analyses.
Benzene	71432	X	X	X	10	11.2%	X	**X**	Identified by at least 2 analyses.
Chloroform	67663	X	X	X	20	3.8%	X	**X**	Identified by at least 2 analyses.
1,2-Dichloroethane (EDC)	107062	X	X	X	18	2.9%	X	**X**	Identified by at least 2 analyses.
Carbon tetrachloride	56235	X	X	X	25	2.7%	X	***O***	Identified by at least 2 analyses, among 3 lowest in proportion of area source contributions.
1,3-Dichloropropene	542756		X	X	15	99.8%	X	**X**	Identified by at least 2 analyses.
Carcinogenic PAHs: 7-PAH		X		X	3	61.8%	X	**X**	Identified by at least 2 analyses.
2,3,7,8-TCDD (dioxin)	1746016		X	X	8	23.5%	X	**X**	Identified by at least 2 analyses.
Hexachlorobenzene	118741		X	X	39	22.3%	X	**X**	Identified by at least 2 analyses.
Polychlorinated biphenyls (PCBs)	1336363		X	X	11	19.9%	X	**X**	Identified by at least 2 analyses.
Acetaldehyde	75070		X	X	19	18.8%	X	**X**	Identified by at least 2 analyses.
Lead and lead compounds	7439921	X	X		42	16.7%	X	**X**	Identified by at least 2 analyses.
Hydrazine, hydrazine sulfate	302012		X	X	35	8.0%	X	**X**	Identified by at least 2 analyses.
Quinoline	91225		X	X	31	6.3%	X	**X**	Identified by at least 2 analyses.
1,2-Dichloropropane (propylene dichloride)	78875		X	X	29	3.6%	X	**X**	Identified by at least 2 analyses.

Table 6. Results of the urban hazardous air pollutant selection process. Hazardous air pollutants to be used in selecting area sources for regulation under CAAA Section 112k are marked with a boldface **X**. HAPs selected for the integrated urban air strategy, but not for area source selection, are marked with an ***O***. HAPs are sorted by 1- availability of publicly reviewed inventory; 2- number of analyses considering it a priority; and 3- ratio of area/total emissions.)

Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	OAQPS Ranking Analysis Top 40		Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
1,2-Dibromoethane	106934		X	X	7	1.5%	X	O	Identified by at least 2 analyses, among 3 lowest in proportion of area source contributions.
Coke Oven Emissions	8007452	X		X	9		X	O	Identified by at least 2 analyses, among 3 lowest in proportion of area source contributions.
1,1,2,2-Tetrachloroethane	79345			X	34	79.5%	X	**X**	Identified by 1 analysis, >25% from area sources.
Mercury and compounds	7439976			X	4	34.5%	X	**X**	Identified by 1 analysis, >25% from area sources.
Beryllium and compounds	7440417		X		56	27.7%	X	**X**	Identified by 1 analysis, >25% from area sources
1,1-Dichloroethylene	75354			X	30	19.3%	X		Identified by 1 analysis, <25% from area sources.
Ethyl acrylate	140885		X		72	12.5%	X		Identified by 1 analysis, <25% from area sources.
Acrylamide	79061		X		47	9.1%	X		Identified by 1 analysis, <25% from area sources.
1,1,2-Trichloroethane	79005		X		52	1.0%	X		Identified by 1 analysis, <25% from area sources.
1,4-Dichlorobenzene	106467				66	86.7%	X		Not identified by any analysis.
4,4'-Methylenediphenyl diisocyanate	101688				77	49.0%	X		Not identified by any analysis.
Bis(2-ethylhexyl)phthalate (DEHP)	117817				68	9.6%	X		Not identified by any analysis.
Styrene	100425				75	6.1%	X		Not identified by any analysis.
Chloromethane (methyl chloride)	74873				48	1.2%	X		Not identified by any analysis.
Xylene (mixed)	1330207	X		X	32	18.6%			No publicly-reviewed inventory.
2-Nitropropane	79469	X		X	24	2.1%			No publicly-reviewed inventory.
Bromomethane (methyl bromide)	74839			X	27	93.0%			No publicly-reviewed inventory.
Cyanide compounds	57125	X			137	58.5%			No publicly-reviewed inventory.
n-Hexane	110543	X			59	30.2%			No publicly-reviewed inventory.
Toluene	108883	X			43	25.2%			No publicly-reviewed inventory.
Naphthalene	91203			X	28	18.6%			No publicly-reviewed inventory.
Glycol ethers		X			44	17.0%			No publicly-reviewed inventory.
Chlorine	7782505			X	40	6.0%			No publicly-reviewed inventory.
N-Nitrosodimethylamine	62759			X	22	4.1%			No publicly-reviewed inventory.
Hydrogen chloride	7647010			X	14	3.2%			No publicly-reviewed inventory.
Heptachlor	76448		X		41	1.6%			No publicly-reviewed inventory.
Hexachlorocyclopentadiene	77474		X		67	1.3%			No publicly-reviewed inventory.
Benzotrichloride	98077		X		45	1.0%			No publicly-reviewed inventory.

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Table 6. Results of the urban hazardous air pollutant selection process. Hazardous air pollutants to be used in selecting area sources for regulation under CAAA Section 112k are marked with a boldface ***X***. HAPs selected for the integrated urban air strategy, but not for area source selection, are marked with an ***O***. HAPs are sorted by 1- availability of publicly reviewed inventory; 2- number of analyses considering it a priority; and 3- ratio of area/total emissions.)

Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	QAQPS Ranking Analysis Top 40		Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
2-Chloro-1,3-butadiene (chloroprene)	126998			***X***	38	0.0%			No publicly-reviewed inventory.
-Acenaphthene	83329				151	100.0%			No publicly-reviewed inventory.
-Fluoranthene	206440				148	100.0%			No publicly-reviewed inventory.
-Fluorene	86737				149	100.0%			No publicly-reviewed inventory.
-Pyrene	129000				150	100.0%			No publicly-reviewed inventory.
2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757				133	100.0%			No publicly-reviewed inventory.
Carbaryl	63252					98.5%			No publicly-reviewed inventory.
Hexamethylene-1,6-diisocyanate	822060				111	94.9%			No publicly-reviewed inventory.
Chlorobenzene	108907				58	84.1%			No publicly-reviewed inventory.
1,3-Propane sultone	1120714				138	70.0%			No publicly-reviewed inventory.
-Tetraethyl lead	78002					67.5%			No publicly-reviewed inventory.
Acetamide	60355				139	63.6%			No publicly-reviewed inventory.
Pentachlorophenol	87865				108	57.6%			No publicly-reviewed inventory.
-Dibenz[a,j]acridine	224420				140	55.0%			No publicly-reviewed inventory.
Dibenzofuran	132649					54.9%			No publicly-reviewed inventory.
Methyl tertbutyl ether (MTBE)	1634044				51	52.5%			No publicly-reviewed inventory.
Hexachloroethane	67721				104	51.3%			No publicly-reviewed inventory.
Triethylamine	121448				90	45.4%			No publicly-reviewed inventory.
Chromium III and compounds	16065831					44.2%			No publicly-reviewed inventory.
Calcium cyanamide	156627					44.0%			No publicly-reviewed inventory.
-Anthracene	120127				144	35.9%			No publicly-reviewed inventory.
Phosphine	7803512				115	35.5%			No publicly-reviewed inventory.
Isophorone	78591				116	35.0%			No publicly-reviewed inventory.
Cobalt and compounds	7440484				117	32.3%			No publicly-reviewed inventory.
1,1,1-Trichloroethane	71556				49	32.2%			No publicly-reviewed inventory.
Methyl hydrazine	60344					31.6%			No publicly-reviewed inventory.
Methanol	67561				100	31.0%			No publicly-reviewed inventory.
Ethyl carbamate (urethane)	51796				71	30.6%			No publicly-reviewed inventory.
-Chrysene	218019					28.8%			No publicly-reviewed inventory.

Table 6. Results of the urban hazardous air pollutant selection process. Hazardous air pollutants to be used in selecting area sources for regulation under CAAA Section 112k are marked with a boldface ***X***. HAPs selected for the integrated urban air strategy, but not for area source selection, are marked with an ***O***. HAPs are sorted by 1- availability of publicly reviewed inventory; 2- number of analyses considering it a priority; and 3- ratio of area/total emissions.)

Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	QAQPS Ranking Analysis Top 40	Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
-Antimony trioxide	1309644			89	28.4%			No publicly-reviewed inventory.
-Benz[a]anthracene	56553				24.8%			No publicly-reviewed inventory.
Antimony and compounds	7440360			64	22.0%			No publicly-reviewed inventory.
1,1-Dimethylhydrazine	57147				21.9%			No publicly-reviewed inventory.
Benzyl chloride	100447			70	18.6%			No publicly-reviewed inventory.
Dimethyl sulfate	77781				18.5%			No publicly-reviewed inventory.
Selenium	7782492			126	18.2%			No publicly-reviewed inventory.
Catechol	120809				18.0%			No publicly-reviewed inventory.
Methyl isobutyl ketone	108101			46	16.4%			No publicly-reviewed inventory.
2,2,4-Trimethylpentane	540841				14.9%			No publicly-reviewed inventory.
Propylene oxide	75569			55	14.4%			No publicly-reviewed inventory.
-Benzo[a]pyrene	50328				14.2%			No publicly-reviewed inventory.
Carbonyl sulfide	463581				13.8%			No publicly-reviewed inventory.
Dibutyl phthalate	84742			132	12.7%			No publicly-reviewed inventory.
Dimethyl phthalate	131113				12.7%			No publicly-reviewed inventory.
Asbestos*	1332214				12.0%			No publicly-reviewed inventory.
-Dibenz[a,h]anthracene	53703				11.4%			No publicly-reviewed inventory.
-Hexachlorodibenzo-p-dioxin mixture	19408743			106	10.0%			No publicly-reviewed inventory.
-Benzo[k]fluoranthene	207089				9.6%			No publicly-reviewed inventory.
-Indeno[1,2,3-cd]pyrene	193395				8.6%			No publicly-reviewed inventory.
-Benzo[b]fluoranthene	205992				8.0%			No publicly-reviewed inventory.
Phthalic anhydride	85449			124	8.0%			No publicly-reviewed inventory.
Methoxychlor	72435			142	8.0%			No publicly-reviewed inventory.
Parathion	56382			145	8.0%			No publicly-reviewed inventory.
Methyl ethyl ketone	78933			73	7.8%			No publicly-reviewed inventory.
Hydrogen fluoride	7664393			60	7.4%			No publicly-reviewed inventory.
Ethylene glycol	107211			103	6.6%			No publicly-reviewed inventory.
Chloroethane (ethyl chloride)	75003			125	6.6%			No publicly-reviewed inventory.
2,4/2,6-Toluene diisocyanate mixture	26471625			63	6.5%			No publicly-reviewed inventory.

Table 6. Results of the urban hazardous air pollutant selection process. Hazardous air pollutants to be used in selecting area sources for regulation under CAAA Section 112k are marked with a boldface ***X***. HAPs selected for the integrated urban air strategy, but not for area source selection, are marked with an *O*. HAPs are sorted by 1- availability of publicly reviewed inventory; 2- number of analyses considering it a priority; and 3- ratio of area/total emissions.)

Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	QAQPS Ranking Analysis Top 40	Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
Chloroacetic acid	79118			143	6.1%			No publicly-reviewed inventory.
1,4-Dioxane	123911			65	6.1%			No publicly-reviewed inventory.
Acetophenone	98862				6.1%			No publicly-reviewed inventory.
Methyl methacrylate	80626			129	5.9%			No publicly-reviewed inventory.
1,1-Dichloroethane	75343			69	5.8%			No publicly-reviewed inventory.
2-Chloroacetophenone	532274			92	5.6%			No publicly-reviewed inventory.
4,4'-Methylenedianiline	101779			86	5.4%			No publicly-reviewed inventory.
N,N-Dimethylformamide	68122			88	5.3%			No publicly-reviewed inventory.
Phenol	108952			96	5.3%			No publicly-reviewed inventory.
Carbon disulfide	75150			84	5.3%			No publicly-reviewed inventory.
Ethylbenzene	100414			82	5.2%			No publicly-reviewed inventory.
Trifluralin	1582098			105	4.6%			No publicly-reviewed inventory.
Ethylene thiourea (ETU)	96457			130	4.6%			No publicly-reviewed inventory.
Aniline	62533			76	4.4%			No publicly-reviewed inventory.
Methyl isocyanate	624839			122	4.2%			No publicly-reviewed inventory.
Acetonitrile	75058			118	3.7%			No publicly-reviewed inventory.
Bis(2-chloroethyl)ether	111444			80	3.7%			No publicly-reviewed inventory.
1,2-Epoxybutane	106887			128	3.1%			No publicly-reviewed inventory.
Pentachloronitrobenzene	82688			98	3.1%			No publicly-reviewed inventory.
Baygon (propoxur)	114261			152	3.0%			No publicly-reviewed inventory.
Methyl iodide	74884				2.9%			No publicly-reviewed inventory.
Chloromethyl methyl ether	107302				2.7%			No publicly-reviewed inventory.
1,1-Biphenyl	92524				2.7%			No publicly-reviewed inventory.
2-Methylaniline (o-toluidine)	95534			94	2.6%			No publicly-reviewed inventory.
Diethanolamine	111422			120	2.5%			No publicly-reviewed inventory.
4,4'-Methylene bis(2-chloroaniline)	101144			127	2.5%			No publicly-reviewed inventory.
4-Nitrophenol	100027				2.4%			No publicly-reviewed inventory.
Epichlorohydrin	106898			78	2.3%			No publicly-reviewed inventory.
Phosgene	75445			112	2.3%			No publicly-reviewed inventory.

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Table 6. Results of the urban hazardous air pollutant selection process. Hazardous air pollutants to be used in selecting area sources for regulation under CAAA Section 112k are marked with a boldface ***X***. HAPs selected for the integrated urban air strategy, but not for area source selection, are marked with an ***O***. HAPs are sorted by 1- availability of publicly reviewed inventory; 2- number of analyses considering it a priority; and 3- ratio of area/total emissions.)

Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	QAQPS Ranking Analysis Top 40	Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
Styrene oxide	96093			141	2.0%			No publicly-reviewed inventory.
Vinyl acetate	108054			109	1.9%			No publicly-reviewed inventory.
2,4-Dinitrotoluene	121142			123	1.8%			No publicly-reviewed inventory.
Acrylic acid	79107			74	1.7%			No publicly-reviewed inventory.
1,2-Propylenimine (2-methyl aziridine)	75558				1.6%			No publicly-reviewed inventory.
Chlordane	57749			102	1.6%			No publicly-reviewed inventory.
Cumene	98828			93	1.5%			No publicly-reviewed inventory.
Diethyl sulfate	64675				1.3%			No publicly-reviewed inventory.
Bis(chloromethyl)ether	542881			54	1.3%			No publicly-reviewed inventory.
Allyl chloride	107051			79	1.2%			No publicly-reviewed inventory.
2,4,6-Trichlorophenol	88062			134	1.2%			No publicly-reviewed inventory.
Benzidine	92875			57	1.0%			No publicly-reviewed inventory.
3,3'-Dichlorobenzidine	91941			110	1.0%			No publicly-reviewed inventory.
Hexachlorobutadiene	87683			50	1.0%			No publicly-reviewed inventory.
1,2-Dibromo-3-chloropropane	96128			99	1.0%			No publicly-reviewed inventory.
2,4,5-Trichlorophenol	95954			147	1.0%			No publicly-reviewed inventory.
3,3'-Dimethoxybenzidine	119904			135	1.0%			No publicly-reviewed inventory.
3,3'-Dimethylbenzidine	119937			97	1.0%			No publicly-reviewed inventory.
4-Nitrobiphenyl	92933				1.0%			No publicly-reviewed inventory.
N-Nitrosomorpholine	59892			85	1.0%			No publicly-reviewed inventory.
4-Aminobiphenyl	92671				1.0%			No publicly-reviewed inventory.
p-Dimethylaminoazobenzene	60117			107	1.0%			No publicly-reviewed inventory.
Nitrobenzene	98953			114	1.0%			No publicly-reviewed inventory.
Hydroquinone	123319				0.9%			No publicly-reviewed inventory.
Titanium tetrachloride	7550450			95	0.9%			No publicly-reviewed inventory.
4,6-Dinitro-2-methylphenol	534521				0.9%			No publicly-reviewed inventory.
Bromoform (tribromomethane)	75252			113	0.9%			No publicly-reviewed inventory.
o-Anisidine	90040				0.7%			No publicly-reviewed inventory.
2,4-Dinitrophenol	51285			146	0.7%			No publicly-reviewed inventory.

Table 6. Results of the urban hazardous air pollutant selection process. Hazardous air pollutants to be used in selecting area sources for regulation under CAAA Section 112k are marked with a boldface ***X***. HAPs selected for the integrated urban air strategy, but not for area source selection, are marked with an ***O***. HAPs are sorted by 1- availability of publicly reviewed inventory; 2- number of analyses considering it a priority; and 3- ratio of area/total emissions.)

Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	OAQPS Ranking Analysis Top 40	Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
1,2,4-Trichlorobenzene	120821			87	0.5%			No publicly-reviewed inventory.
Maleic anhydride	108316			61	0.4%			No publicly-reviewed inventory.
N-N-Dimethylaniline	121697				0.4%			No publicly-reviewed inventory.
p-Phenylenediamine	106503				0.3%			No publicly-reviewed inventory.
Propionaldehyde	123386				0.2%			No publicly-reviewed inventory.
Cresols/cresylic acid (isomers and mixture)	1319773			53	0.2%			No publicly-reviewed inventory.
Dichlorvos	62737			131	0.1%			No publicly-reviewed inventory.
-Hydrogen cyanide	74908							No publicly-reviewed inventory.
-Free cyanide	57125							No publicly-reviewed inventory.
Vinyl bromide	593602			121				No publicly-reviewed inventory.
2-Acetylaminofluorene	53963							No publicly-reviewed inventory.
Caprolactam	105602							No publicly-reviewed inventory.
Captan	133062			136				No publicly-reviewed inventory.
Chloramben	133904							No publicly-reviewed inventory.
Chlorobenzilate	510156			101				No publicly-reviewed inventory.
2-Methylphenol (o-cresol)	95487							No publicly-reviewed inventory.
3-Methylphenol (m-cresol)	108394							No publicly-reviewed inventory.
4-Methylphenol (p-cresol)	106445							No publicly-reviewed inventory.
DDE	72559			62				No publicly-reviewed inventory.
Diazomethane	334883							No publicly-reviewed inventory.
Dimethyl carbamoyl chloride	79447							No publicly-reviewed inventory.
Dinitrotoluene mixture	25321146							No publicly-reviewed inventory
1,2-Diphenylhydrazine	122667							No publicly-reviewed inventory.
Ethylene imine (aziridine)	151564							No publicly-reviewed inventory.
Hexamethylphosphoramide	680319							No publicly-reviewed inventory.
alpha-Hexachlorocyclohexane (a-HCH)	319846							No publicly-reviewed inventory.
beta-Hexachlorocyclohexane (b-HCH)	319857							No publicly-reviewed inventory.
gamma-Hexachlorocyclohexane (g-HCH,Lindane)	58899							No publicly-reviewed inventory.
technical Hexachlorocyclohexane (HCH)	608731							No publicly-reviewed inventory.

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Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	QAQPS Ranking Analysis Top 40	Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
N-Nitroso-N-methylurea	684935							No publicly-reviewed inventory.
Phosphorus (white)	7723140							No publicly-reviewed inventory.
beta-Propiolactone	57578							No publicly-reviewed inventory.
Quinone	106514							No publicly-reviewed inventory.
Toluene-2,4-diamine	95807							No publicly-reviewed inventory.
Toxaphene	8001352							No publicly-reviewed inventory.
o-Xylene	95476			83				No publicly-reviewed inventory.
m-Xylene	108383			81				No publicly-reviewed inventory.
p-Xylene	106423			91				No publicly-reviewed inventory.
-Antimony pentafluoride	7783702							No publicly-reviewed inventory.
-Antimony pentoxide	1314609							No publicly-reviewed inventory.
-Antimony potassium tartrate	304610							No publicly-reviewed inventory.
-Antimony tetroxide	1332816							No publicly-reviewed inventory.
-Arsine	7784421							No publicly-reviewed inventory.
-Arsenic oxide	1327533							No publicly-reviewed inventory.
-Arsenic pentoxide	1303282							No publicly-reviewed inventory.
-Cadmium oxide	1306190							No publicly-reviewed inventory.
-Chromic chloride	10025737							No publicly-reviewed inventory.
-Cobalt carbonyl	10210681							No publicly-reviewed inventory.
-Barium cyanide	542621							No publicly-reviewed inventory.
-Calcium cyanide	592018							No publicly-reviewed inventory.
-Chlorine cyanide	506774							No publicly-reviewed inventory.
-Copper cyanide	544923							No publicly-reviewed inventory.
-Cyanazine	21725462							No publicly-reviewed inventory.
-Cyanogen	460195							No publicly-reviewed inventory.
-Cyanogen bromide	506683							No publicly-reviewed inventory.
-Cyanogen chloride	506774							No publicly-reviewed inventory.
-Potassium cyanide	151508							No publicly-reviewed inventory.
-Potassium silver cyanide	506616							No publicly-reviewed inventory.

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Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	QAQPS Ranking Analysis Top 40	Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
-Silver cyanide	506649							No publicly-reviewed inventory.
-Sodium cyanide	143339							No publicly-reviewed inventory.
-Thiocyanate	THIOCYANATE							No publicly-reviewed inventory.
-Zinc cyanide	557211							No publicly-reviewed inventory.
-Diethylene glycol, monobutyl ether	112345							No publicly-reviewed inventory.
-Diethylene glycol, monoethyl ether	111900							No publicly-reviewed inventory.
-2-Ethoxyethanol (ethylene glycol ethyl e	110805							No publicly-reviewed inventory.
-Ethylene glycol monobutyl ether	111762							No publicly-reviewed inventory.
-2-Methoxyethanol acetate	110496							No publicly-reviewed inventory.
-2-Methoxyethanol	109864							No publicly-reviewed inventory.
-Tetramethyl lead	75741							No publicly-reviewed inventory.
-Methylcyclopentadienyl manganese	12108133							No publicly-reviewed inventory.
-Mercury (elemental)	7439976							No publicly-reviewed inventory.
-Mercuric chloride	7487947							No publicly-reviewed inventory.
-Mercury (methyl)	22967926							No publicly-reviewed inventory.
-Nickel refinery dust	NI_DUST							No publicly-reviewed inventory.
-Nickel subsulfide	12035722							No publicly-reviewed inventory.
Polycyclic Organic Matter	POM							No publicly-reviewed inventory.
-Carbazole	86748							No publicly-reviewed inventory.
-Dibenz[a,h]acridine	226368							No publicly-reviewed inventory.
-7H-Dibenzo[c,g]carbazole	194592							No publicly-reviewed inventory.
-Dibenzo[a,e]pyrene	192654			119				No publicly-reviewed inventory.
-Dibenzo[a,i]pyrene	189559							No publicly-reviewed inventory.
-Dibenzo[a,l]pyrene	191300							No publicly-reviewed inventory.
-7,12-Dimethylbenz[a]anthracene	57976							No publicly-reviewed inventory.
-1,6-Dinitropyrene	42397648							No publicly-reviewed inventory.
-1,8-Dinitropyrene	42397659							No publicly-reviewed inventory.
-3-Methylcholanthrene	56495							No publicly-reviewed inventory.
-5-Methylchrysene	3697243							No publicly-reviewed inventory.

Table 6. Results of the urban hazardous air pollutant selection process. Hazardous air pollutants to be used in selecting area sources for regulation under CAAA Section 112k are marked with a boldface ***X***. HAPs selected for the integrated urban air strategy, but not for area source selection, are marked with an ***O***. HAPs are sorted by 1- availability of publicly reviewed inventory; 2- number of analyses considering it a priority; and 3- ratio of area/total emissions.)

Contaminant	CAS #	ERG Study Survey	CEP Urban Analysis --All Sources	OAQPS Ranking Analysis Top 40	Ratio of Area/Total Emissions	Publicly-Reviewed Emission Data	Selected for 112k	Notes
-2-Methylnaphthalene	91576							No publicly-reviewed inventory.
-5-Nitroacenaphthene	602879							No publicly-reviewed inventory.
-6-Nitrochrysene	2043937							No publicly-reviewed inventory.
-2-Nitrofluorene	607578							No publicly-reviewed inventory.
-2-Nitrofluorene	607578							No publicly-reviewed inventory.
-1-Nitropyrene	5522430							No publicly-reviewed inventory.
-4-Nitropyrene	57835924							No publicly-reviewed inventory.
-Hydrogen selenide	2148909							No publicly-reviewed inventory.
-Selenious Acid	7783008							No publicly-reviewed inventory.
-Sodium selenate	13410010							No publicly-reviewed inventory.
-Sodium selenite	10102188							No publicly-reviewed inventory.

APPENDIX A:

Summary of Hazardous Air Pollutant Rankings

Based on Results from Existing Risk Assessments and Hazard Rankings

April, 1998

Eastern Research Group, Inc.

For the Office of Air Quality Planning and Standards

Eastern Research Group, Inc.

MEMORANDUM

TO: Roy Smith and Deirdre Murphy, EPA/OAQPS

FROM: Richard Billings, Regi Oommen, and Adam Langmaid, ERG

CC: Laura McKelvey, EPA/OAQPS
Anne Pope, EPA/OAQPS
Garry Brooks, ERG
Darcy Wilson, ERG

DATE: April 10, 1998

SUBJECT: Summary of Hazardous Air Pollutant Rankings

1.0 Summary

Section 112(k) of the Clean Air Act Amendments (CAAA) of 1990 requires that the U.S. Environmental Protection Agency (U.S. EPA) identify no less than 30 hazardous air pollutants (HAPs) that, as the result of emissions from area sources, present the greatest threat to public health in the largest number of urban areas. Work Assignment No. III-66 for EPA Contract No. 68-D3-0033 was initiated to develop data pertinent to the identification of HAPs of greatest concern to urban areas. One of the products of this Work Assignment was a draft study of urban risk assessments and hazard rankings. In follow on Work Assignment No. I-10 for EPA Contract No. 68-D7-0068, the risk assessments and hazard rankings were reevaluated based on expert review comments; this memorandum is the product of this revision.

The data compiled in this memorandum include risk assessments as well as hazard rankings for carcinogenic and noncarcinogenic effects. The data in the compiled studies were normalized based on an individual pollutant's contribution to risk/hazard in the defined study areas. Normalizing risk and hazard ranking scores allowed for some comparison among the studies.

The risk assessments take results from dispersion modeling of inventory data, ambient air studies, or a combination of modeled and ambient studies to estimate the magnitude of an adverse effect. On the other hand, hazard ranking studies simply combine emission inventory results with toxic characteristics to provide a rough indication of the relative risks associated with emissions of each HAP. It should also be noted that the studies used in this report included emission sources other than area sources.

The result of these efforts was the identification of the following pollutants as being of greatest potential concern for urban areas:

Carcinogenic Compounds

Acrylonitrile	Chromium Compounds[1]	2-Nitropropane
Arsenic Compounds	Coke Oven Gases	Polycyclic Organic Matter
Benzene[1]	Ethylene Dichloride	Tetrachloroethylene
1,3-Butadiene	Ethylene Oxide	Trichloroethylene
Cadmium Compounds	Formaldehyde	Vinyl Chloride
Carbon Tetrachloride[1]	Methylene Chloride	
Chloroform[1]	Nickel Compounds[1]	

Noncarcinogenic Compounds

Acrolein	Cyanide Compounds	Nickel Compounds[1]
Benzene[1]	Glycol Ethers	Toluene
Carbon Tetrachloride[1]	Hexane	Xylene
Chloroform[1]	Lead Compounds	
Chromium Compounds[1]	Manganese Compounds	

Section 2 of this memorandum provides background information about the intent of this study and summary details about the risk assessments and hazard rankings used in this study. The approach used to compare the results of the individual studies is discussed in Section 3. Section 4 explains how the HAPs of greatest concern were identified and lists the specific pollutants of concern. All references used in this study are noted in Section 5. Supporting tables and graphics are provided at the end of this report.

2.0 Background

The intent of this memorandum is to identify HAPs of concern to urban areas based on results from existing risk assessments and hazard rankings for carcinogenic and noncarcinogenic endpoints.

[1] Included as both carcinogenic and noncarcinogenic pollutants.

In a risk assessment, the expected or actual concentration of a given pollutant for a given community is taken into consideration along with the toxic characteristics of the pollutant when assessing the effects the emissions may yield. In this evaluation, 74% of the 23 ranking studies were risk assessments. In one study, ambient test data were used as the basis for the risk assessment; in all other studies, emission inventory data were modeled to estimate the expected concentration of a pollutant. Some of the studies used both emission inventory data to model the concentration and a limited amount of ambient data to validate the modeled results.

Hazard ranking studies adjust emission inventory data by taking into consideration toxic characteristics of the pollutants. Hazard ranking studies do not take into consideration the expected level of exposure of a pollutant. Even though hazard rankings stop short of estimating the expected level of exposure of a pollutant, these studies are useful for the purpose of this report, because they rank pollutants of concern based on more than just emissions. About 30% of the 23 ranking studies included in this report used the hazard ranking approach. About 9% of the studies used approaches that were not clearly defined in the documentation, but it was determined that the results of those studies would still be useful in this exercise.[2]

The studies reviewed and discussed in this memorandum are introduced in Table 2.1, along with relevant information about the basis for the ranking, baseline year, geographical location, type of ranking, number of pollutants, and types of sources included in each of the studies. For the most part, the studies reviewed were for urban areas, although several studies were for non-urban areas. The non-urban studies were not used in identifying urban area HAPs.

Three of the studies (Philadelphia, South Coast, and Minneapolis/St. Paul) were not included in the ranks of aggregated normalized scores because these three studies were for a small number of pollutants, which meant that normalized scores for the pollutants in these studies were, on average, higher than scores for pollutants in studies that had a larger number of pollutants.

Sources of data used to develop inventories for both the risk assessment and hazard rankings included speciation of National Acid Precipitation Assessment Program (NAPAP) (26%) or State Implementation Plan (SIP) (17%) inventories, Toxic Release Inventory (TRI) reporting (43%), and local permit data or surveys of local industries (43%). In some cases, the basis for the inventory was unclear.[3]

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[2] Note: The total percentage of all study types is greater than 100% because some of the studies (e.g. Arizona's) used both risk assessments and hazard rankings.

[3] Note: The percentages do not add up to 100% because many of the inventories used several approaches to quantify emissions.

Of the 23 studies identified in the memorandum, approximately 60% concerned carcinogenic endpoints, while 40% of the studies considered both carcinogenic and noncarcinogenic endpoints. In this memorandum, carcinogenic and noncarcinogenic results are handled separately.

The baseline years for which the studies were developed range from 1980 to 1995. The distribution of the base years is as follows: 1980 (22%), 1984 (4%), 1985 (17%), 1986 (4%), 1988 (4%), 1990 (22%), 1994 (17%), 1995 (4%), and 4% of the studies were for an undefined base year.[4]

The studies also did not always include the same types of source categories. Of the ranking studies reviewed, 74% combined point, area, and mobile sources, 13% quantified emissions from only point and area sources, and 13% of the studies were for area sources only.

3.0 Methodology

The evaluation of the studies was done in two stages. In the first stage, the results of individual studies were expressed in terms that would allow comparison between different studies that may have used very different ranking scales. In the second stage of this evaluation, results from the studies were compared to similar studies in order to identify the pollutants of greatest potential concern.

3.1 Normalized Scores

To allow for ranking of pollutants across studies, the results of each of the risk assessment/hazard ranking studies were normalized based on the total score of the individual studies. In some cases, these scores are risk values, percent contribution to risk, or weighted hazard scores. If in a given study benzene received a hazard score of 40 and the total of all the hazard scores in the study was 100, then the normalized score for benzene would be 0.40 or (40/100). The normalization of these numbers in this fashion can be interpreted as percentage of risk or hazard that a pollutant contributes to the study area. This approach also makes it possible to retain the relative distribution of the pollutants, not merely the order of the ranking.

Comparisons of the normalized risk assessment/hazard ranking results are summarized in Table 3.1 for carcinogenic endpoints and in Table 3.2 for noncarcinogenic endpoints. Pollutants listed in these tables were reported using the nomenclature of the studies cited. The 188 HAP synonyms are noted in the associated footnotes.

[4] Note: The percentages do not add up to 100% because of error associated with rounding off the percentages.

3.2 Comparison Between Studies

The normalized scores of individual studies were summed for each pollutant for two specific scenarios. The pollutants were then ranked based on these aggregated scores.

The first scenario considered normalized scores for only studies that included point, area, and mobile sources. This would include the most complete studies and exclude studies which were not similar. All of the point, area, and mobile studies were risk assessments, so their general approaches were relatively similar. Results for the ranking of point, area, and mobile studies are provided in Table 3.3 for carcinogenic endpoints and in Table 3.4 for noncarcinogenic endpoints. The distributions of these rankings are also represented in Figures 3.1 and 3.2, respectively, for carcinogenic and noncarcinogenic endpoints. The distribution appears to be log normal, in that a small number of pollutants have very high aggregated normalized scores, a larger set of pollutants have lower scores, and a still larger number of pollutants have low scores which are very similar. The pollutants of greatest potential concern were considered to be those that are not included in the long tail (the flat horizontal section) of the distribution. These pollutants of greatest potential concern are represented as dots in Figures 3.1 and 3.2 and are also included in the shaded portion in Tables 3.3 and Table 3.4.

A similar ranking was performed on studies that included only area sources, again so that similar studies were compared to each other. All of the area source studies were hazard ranking studies, so their general approaches were similar. This ranking was limited to only three studies. These results are provided in Table 3.5 for carcinogenic endpoints and Table 3.6 for noncarcinogenic endpoints as well as in Figures 3.3 and 3.4.

4.0 Results

The pollutants whose names are shaded in the Tables 3.3, 3.4, 3.5, and 3.6 were compiled into the following list of pollutants of greatest potential concern for urban areas. Pollutants that are not on the 188 HAPs listed in Section 112(b) of the 1990 CAAA were not included in this final listing.

Carcinogenic Compounds

Acrylonitrile	Chromium Compounds[5]	2-Nitropropane
Arsenic Compounds	Coke Oven Emissions	Polycyclic Organic Matter
Benzene[5]	Ethylene Dichloride	Tetrachloroethylene
1,3-Butadiene	Ethylene Oxide	Trichloroethylene
Cadmium Compounds	Formaldehyde	Vinyl Chloride
Carbon Tetrachloride[5]	Methylene Chloride	
Chloroform[5]	Nickel Compounds[5]	

Noncarcinogenic Compounds

Acrolein	Cyanide Compounds	Nickel Compounds[5]
Benzene[5]	Glycol Ethers	Toluene
Carbon Tetrachloride[5]	Hexane	Xylene
Chloroform[5]	Lead Compounds	
Chromium Compounds[5]	Manganese Compounds	

[5] Included as both carcinogenic and noncarcinogenic pollutants.

5.0 References

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TABLE 2.1 - CHARACTERISTICS OF RISK ASSESSMENT/HAZARD RANKING STUDIES

Study	Reference	Type of Study (Emissions or Ambient Monitoring)	Geographical Area	Date of Baseline	Source of Inventory Data	Source Types	Carcinogen/ Noncarcinogen	Number of Pollutants	Basis for Ranking
Staten Island/NJ Urban Air Toxics Assessment Project (1993)	7	Inventory and Monitoring	Staten Island area	1988-1989	1988 TRI data; NYC, NY, and NJ state data	Point, Area, Mobile	Both	12	Risk Assessment
Summary of Urban Air Toxics Risk Assessment Screening Studies - Five City (1989)	4	Inventory and Monitoring	5 unknown urban regions	1980-1987	1980 NAPAP, with improvements	Point, Area, Mobile	Carcinogen	16	Risk Assessment
Summary of Urban Air Toxics Risk Assessment Screening Studies - Kanawha Valley (1995)	8	Inventory and Monitoring	Kanawha, WV	1980-1987	1980 NAPAP, with improvements	Point, Area, Mobile	Carcinogen	14	Risk Assessment
Summary of Urban Air Toxics Risk Assessment Screening Studies - Philadelphia (1995)	8	Inventory and Monitoring	Philadelphia area	1980-1987	1980 NAPAP, with improvements	Point, Area, Mobile	Carcinogen	5	Risk Assessment
Summary of Urban Air Toxics Risk Assessment Screening Studies - South Coast (1995)	8	Inventory and Monitoring	Los Angeles County region	1980-1987	1980 NAPAP, with improvements	Point, Area, Mobile	Carcinogen	4	Risk Assessment
Summary of Urban Air Toxics Risk Assessment Screening Studies - Southeast Chicago (1995)	8	Inventory and Monitoring	Southeast Chicago	1980-1987	1980 NAPAP, with improvements	Point, Area, Mobile	Carcinogen	16	Risk Assessment
Houston Area Source Toxic Emission (HASTE) Project (1996)	13	Inventory	Houston area	1995	Houston-Galveston ozone SIP inventory, HAP emission inventories, survey, Texas Point Source database	Area	Both	24	Hazard Rank
Connecticut's Process for Prioritizing Hazardous Air Pollutants (1991)	9	Inventory	Connecticut - statewide	1990	TRI (and other sources not mentioned)	Point, Area	Both	24	Other
Transboundary Air Toxics Study (1990)	2	Inventory	Great Lakes region	1985	1985 NAPAP and AIRS; state, provincial, local, county, TRI, and NESHAP inventory; Mobile3 to estimate hydrocarbon emissions (speciation)	Point, Area, Mobile	Carcinogen	27	Risk Assessment
Calculating Emission-based Hazard Indices for HAPs (1992)	1	Inventory	Nationwide	1990	1990 TRI, IEMP, and UATES studies	Point, Area	Carcinogen	44	Hazard Ranking
Arizona Hazardous Air Pollutant Research Program - Phoenix (1995)	3	Inventory	Phoenix area	1994	TRI and permit files from ADEQ	Point, Area, Mobile	Both	19	Both
Arizona Hazardous Air Pollutant Research Program - Tucson (1995)	3	Inventory	Tucson area	1994	TRI and permit files from ADEQ	Point, Area, Mobile	Both	16	Both
Arizona Hazardous Air Pollutant Research Program - Casa Grande (1995)	3	Inventory	Casa Grande area	1994	TRI and permit files from ADEQ	Point, Area, Mobile	Both	15	Both
Arizona Hazardous Air Pollutant Research Program - Payson (1995)	3	Inventory	Payson area	1994	TRI and permit files from ADEQ	Point, Area, Mobile	Both	15	Both
EPA Cancer Risk from Outdoor Exposure to Air Toxics - Nationwide (1990)	5	Inventory	Nationwide	1985	IEMP studies, NESHAP/ATERIS database, TRI	Point, Area	Carcinogen	26	Risk Assessment
Setting Priorities for Air Toxics in California (1994)	14	Inventory	Statewide	1985-1993	Unknown	Point, Area, Mobile	Carcinogen	20	Other

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TABLE 2.1 -CHARACTERISTICS OF RISK ASSESSMENT/HAZARD RANKING STUDIES (CONTINUED)

Study	Reference	Type of Study (Emissions or Ambient Monitoring)	Geographical Area	Date of Baseline	Source of Inventory Data	Source Types	Carcinogen/ Noncarcinogen	Number of Pollutants	Basis for Ranking
Summary of Urban Air Toxics Risk Assessment Screening Studies - Southwest Chicago (1995)	8	Inventory and Monitoring	Southwest Chicago	1990	1990 TRI, RCRA permits, Illinois EPA records	Point, Area, Mobile	Carcinogen	30	Risk Assessment
Summary of Urban Air Toxics Risk Assessment Screening Studies - Baltimore (1995)	8	Inventory and Monitoring	Baltimore area	1985	1983-1987 monitoring data, survey, estimation of hydrocarbon emissions from Mobile3 computer (speciation)	Point, Area, Mobile	Carcinogen	11	Risk Assessment
Santa Clara (1988)	6	Inventory	Santa Clara area	1984	AIRS, local data from Bay Area AQMD	Point, Area, Mobile	Carcinogen	15	Risk Assessment
Estimation and Evaluation of Cancer Risks from Air Pollution in the Minneapolis/St. Paul MSA (1992)	10	Inventory	Minneapolis/St. Paul. MSA	1986	State emissions inventory; TRI; survey; source specific (Ford and Hennepin), Mobile4 estimations	Point, Area, Mobile	Carcinogen	8	Risk Assessment
Urban Area Source Program	9	Inventory and Monitoring	3 urban areas	Unknown	Emission inventories from the three cities	Point, Area, Mobile	Carcinogen	34	Risk Assessment
Development of Area Source Hazardous Air Pollutants Inventory: Chicago (1995)	11	Inventory	Chicago area	1990	Chicago HAP emission inventory, Illinois SIP inventory	Area	Both	21	Hazard Ranking
Development of Area Source Hazardous Air Pollutants Inventory: Seattle-Tacoma (1995)	12	Inventory	Seattle-Tacoma area	1990	Survey, State of Washington permit system, 1990 SIP inventory for Seattle-Tacoma	Area	Both	17	Hazard Ranking

TABLE 3.1 - NORMALIZED RANKINGS OF CARCINOGENIC EFFECTS

Staten Island/New Jersey		Summary of Urban Air Toxics Risk Assessment Screening Studies - Five City		Summary of Urban Air Toxics Risk Assessment Screening Studies - Kanawha Valley		Summary of Urban Air Toxics Risk Assessment Screening Studies - Philadelphia		Summary of Urban Air Toxics Risk Assessment Screening Studies- South Coast		Summary of Urban Air Toxics Risk Assessment Screening Studies - Southeast Chicago	
Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score
Benzene	0.325	Polycyclic Organic Matter	0.297	Ethylene Oxide	0.484	Ethylene Dichloride	0.449	Benzene	0.519	Coke Oven Emissions	0.280
Chromium	0.244	Chromium (VI)	0.186	1,3-Butadiene	0.253	Gasoline Vapors	0.337	Chromium (VI)	0.454	Chromium (VI)	0.156
Arsenic Compounds	0.163	Formaldehyde	0.186	Acrylonitrile	0.108	Tetrachloroethylene	0.112	Cadmium Compounds	0.026	Formaldehyde	0.156
Carbon Tetrachloride	0.096	1,3-Butadiene	0.167	Chloroform	0.109	Trichloroethylene	0.056	Ethylene Dibromide	0.001	Polycyclic Organic Matter	0.124
Nickel Compounds	0.050	Benzene	0.093	Benzene	0.023	Benzene	0.045			1,3-Butadiene	0.093
Chloroform	0.049	Ethylene Oxide	0.019	Arsenic Compounds	0.012					Benzene	0.062
Cadmium Compounds	0.041	Arsenic Compounds	0.013	Methylene Chloride	0.002					Carbon Tetrachloride	0.062
Methylene Chloride	0.010	Ethylene Dichloride	0.009	Cadmium Compounds	0.002					Gasoline Vapors	0.031
Tetrachloroethylene	0.008	Gasoline Vapors	0.009	Tetrachloroethylene	0.002					Arsenic Compounds	0.016
Trichloroethylene	0.007	Carbon Tetrachloride	0.006	Polycyclic Organic Matter	0.002					Cadmium Compounds	0.009
Benzo(a)pyrene	0.003	Tetrachloroethylene	0.006	Ethylene Dibromide	0.001					Ethylene Oxide	0.006
Formaldehyde	0.002	Methylene Chloride	0.004	Vinylidene Chloride	0.001					Trichloroethylene	0.002
		Chloroform	0.002	Trichloroethylene	0.001					Ethylene Dibromide	0.001
		Trichloroethylene	0.002	Ethylene Dichloride	<0.001					Ethylene Dichloride	0.001
		Cadmium Compounds	0.002							Tetrachloroethylene	<0.001
		Vinyl Chloride	<0.001							Dioxins	<0.001

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TABLE 3.1 - NORMALIZED RANKINGS OF CARCINOGENIC EFFECTS (CONTINUED)

HASTE		Connecticut		Transboundary Air Toxics Study		Calculating Emission-Based Hazard Indices for HAPs		Arizona Hazardous Air Pollutant Research Program - Phoenix		Arizona Hazardous Air Pollutant Research Program - Tuscon	
Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score
Vinyl Chloride	0.368	Benzene	0.060	Formaldehyde	0.361	Chromium (VI)	0.501	1,3-Butadiene	0.597	1,3-Butadiene	0.610
Acrylonitrile	0.184	Formaldehyde	0.057	Coke Oven Emissions	0.164	Asbestos	0.304	Benzene	0.120	Benzene	0.129
2-Nitropropane	0.164	1,3-Butadiene	0.057	1,3-Butadiene	0.152	1,3-Butadiene	0.058	Formaldehyde	0.105	Formaldehyde	0.105
1,3-Butadiene	0.055	Cadmium Compounds	0.050	Carbon Tetrachloride	0.140	Benzene	0.039	Arsenic Compounds	0.036	Arsenic Compounds	0.041
Benzene	0.037	Tetrachloroethylene	0.050	Chromium (VI)	0.380	Vinyl Chloride	0.039	Cadmium Compounds	0.036	Cadmium Compounds	0.036
Ethylene Dibromide	0.037	Chloroform	0.047	Polycyclic Organic Matter	0.033	Formaldehyde	0.017	Chloroform	0.027	Nickel Compounds	0.022
Ethylene Oxide	0.037	Polycyclic Organic Matter	0.046	Dioxins	0.032	Arsenic Compounds	0.010	Nickel Compounds	0.020	Chloroform	0.016
Ethylene Dichloride	0.018	Methyl Chloroform	0.046	Arsenic Compounds	0.020	Cadmium Compounds	0.007	p-Dichlorobenzene	0.013	p-Dichlorobenzene	0.011
1,1,2,2-Tetrachloroethane	0.017	Styrene	0.046	Beryllium Compounds	0.016	Nickel Compounds	0.007	Chromium (VI)	0.009	Chromium (VI)	0.007
Cadmium Compounds	0.015	Trichloroethylene	0.045	Asbestos	0.015	Ethylene Oxide	0.004	Ethylene Oxide	0.009	Trichloroethylene	0.005
Formaldehyde	0.013	Ethylene Oxide	0.044	Benzene	0.013	Tetrachloroethylene	0.004	Trichloroethylene	0.009	Acetaldehyde	0.005
Vinylidene Chloride	0.009	Nickel Compounds	0.044	Gasoline Vapors	0.008	Ethylene Dichloride	0.002	Acetaldehyde	0.006	Ethylene Oxide	0.005
Carbon Tetrachloride	0.007	Acrylonitrile	0.043	Cadmium Compounds	0.004	Methylene Chloride	0.002	Methylene Chloride	0.004	Methylene Chloride	0.003
Chloroform	0.007	Vinyl Chloride	0.042	Benzo(a)pyrene	0.002	Trichloroethylene	0.001	Tetrachloroethylene	0.003	Tetrachloroethylene	0.002
Methylene Chloride	0.006	Methyl Chloride	0.041	Ethylene Dibromide	0.002	Chloroform	0.001	Ethylene Dibromide	0.002	Benzo(a)pyrene	0.001
1,1,2-Trichloroethane	0.002	Carbon Tetrachloride	0.039	Vinyl Chloride	0.001	Ethylene Dibromide	0.001	Acrylonitrile	0.001	Carbon Tetrachloride	0.001
Arsenic Compounds	0.001	Arsenic Compounds	0.036	Trichloroethylene	0.001	Propylene Dichloride	0.001	Benzo(a)pyrene	0.001		
Propylene Oxide	0.001	Dioxins	0.035	Tetrachloroethylene	0.001	Acrylonitrile	0.001	Vinyl Chloride	0.001		
Dioxins	0.001	Beryllium Compounds	0.032	PCBs[2]	<0.001	Acetaldehyde	<0.001	Carbon Tetrachloride	<0.001		
Nickel Compounds	<0.001	Chromium (VI)	0.031	Styrene	<0.001	Lead Compounds	<0.001				
Beryllium Compounds	<0.001	PAHs[1]	0.029	Chloroform	<0.001	Beryllium Compounds	<0.001				
Methyl Chloride	<0.001	Acrylamide	0.029	Ethylene Oxide	<0.001	Hexachlorobenzene	<0.001				
Acetaldehyde	<0.001	Methylene Chloride	0.027	Acrylonitrile	<0.001	Methyl Chloride	<0.001				
Epichlorohydrin	<0.001	PCBs	0.023	Methylene Chloride	<0.001	Propylene Oxide	<0.001				
				Chlordane	<0.001	Carbon Tetrachloride	<0.001				
				Heptachlor	<0.001	Vinyl Acetate	<0.001				
				Epichlorohydrin	<0.001	Chloromethyl Ether	<0.001				
						Styrene	<0.001				
						Selenium	<0.001				
						Acrylamide	<0.001				
						PCBs[2]	<0.001				
						Vinylidene Chloride	<0.001				
						Ethylidene Chloride	<0.001				
						Chloromethyl Methyl	<0.001				
						1,1,2-Trichloroethane	<0.001				
						Aniline	<0.001				
						Hydrazine	<0.001				
						1,4-Dioxane	<0.001				
						Isophorone	<0.001				
						Chlordane	<0.001				
						Carbamic Acid	<0.001				
						Captan	<0.001				
						Epichlorohydrin	<0.001				
						Bromoform	<0.001				

TABLE 3.1 - NORMALIZED RANKINGS OF CARCINOGENIC EFFECTS (CONTINUED)

Arizona Hazardous Air Pollutant Research Program - Casa Grande		Arizona Hazardous Air Pollutant Research Program - Payson		EPA Cancer Risk from Outdoor Exposure to Air Toxics - Nationwide		Setting Priorities for Air Toxics Control in California		Summary of Urban Air Toxics Risk Assesment Screening Studies- Southwest Chicago		Summary of Urban Air Toxics Risk Assesment Screening Studies- Baltimore	
Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score
1,3-Butadiene	0.501	1,3-Butadiene	0.592	PICs[3]	0.354	Benzene	0.449	1,3-Butadiene	0.227	Polycyclic Organic Matter	0.632
Benzene	0.123	Formaldehyde	0.132	1,3-Butadiene	0.121	1,3-Butadiene	0.165	Chromium (VI)	0.194	Chromium (VI)	0.146
Formaldehyde	0.122	Benzene	0.116	Chromium (VI)	0.094	Carbon Tetrachloride	0.075	Polycyclic Organic Matter	0.194	Arsenic Compounds	0.049
Chromium (VI)	0.072	Cadmium Compounds	0.078	Benzene	0.082	Chromium (VI)	0.062	Formaldehyde	0.162	Benzene	0.049
Arsenic Compounds	0.064	Chromium (VI)	0.020	Formaldehyde	0.056	Asbestos	0.033	Carbon Tetrachloride	0.065	Methylene Chloride	0.049
Cadmium Compounds	0.064	Arsenic Compounds	0.018	Chloroform	0.052	Formaldehyde	0.031	Coke Oven Emissions	0.065	Formaldehyde	0.029
Benzo(a)pyrene	0.026	Benzo(a)pyrene	0.018	Asbestos	0.040	Dioxins	0.029	Benzene	0.032	Cadmium Compounds	0.019
Nickel Compounds	0.014	Chrysene	0.011	Arsenic Compounds	0.031	Vinyl Chloride	0.022	Arsenic Compounds	0.013	Tetrachloroethylene	0.015
p-Dichlorobenzene	0.008	Nickel Compounds	0.010	Ethylene Dibromide	0.031	Tetrachloroethylene	0.020	Gasoline Vapors	0.013	Trichloroethylene	0.010
Acetaldehyde	0.005	Acetaldehyde	0.004	Dioxins	0.029	Acetaldehyde	0.020	Ethylene Oxide	0.010	Ethylene Dibromide	0.001
Trichloroethylene	0.004	Chloroform	0.001	Gasoline Vapors	0.022	Ethylene Oxide	0.018	Hexachlorobenzene	0.006	Ethylene Dichloride	0.001
Chloroform	0.003	p-Dichlorobenzene	0.001	Ethylene Dichloride	0.020	Ethylene Dichloride	0.018	Tetrachloroethylene	0.003		
Pentachloronitrobenzene	0.003	Ethylene Oxide	<0.001	Carbon Tetrachloride	0.019	Arsenic Compounds	0.009	Trichloroethylene	0.003		
Methylene Chloride	0.002	Tetrachloroethylene	<0.001	Vinyl Chloride	0.011	Methylene Chloride	0.009	Cadmium Compounds	0.003		
Lead Compounds	<0.001	Methylene Chloride	<0.001	Acrylonitrile	0.006	Cadmium Compounds	0.007	Chloroform	0.003		
				Cadmium Compounds	0.005	Ethylene Dibromide	0.007	Methylene Chloride	0.003		
				Vinylidene Chloride	0.005	Nickel Compounds	0.002	Asbestos	0.002		
				Hexachlorobutadiene	0.004	Trichloroethylene	0.002	Dioxins	0.001		
				Coke Oven Emissions	0.003	Chloroform	0.002	Vinyl Chloride	0.001		
				Trichloroethylene	0.003	Benzo(a)pyrene	0.002	Ethylene Dibromide	<0.001		
				Hydrazine	0.003			Ethylene Dichloride	<0.001		
				Tetrachloroethylene	0.003			Acrylonitrile	<0.001		
				Ethylene Oxide	0.003			Vinylidene Chloride	<0.001		
				Methylene Chloride	0.002			Methyl Chloride	<0.001		
				Radionuclides	0.001			Styrene	<0.001		
				Radon	0.001			Acrylamide	<0.001		
								Epichlorohydrin	<0.001		
								Propylene Oxide	<0.001		
								PCBs[2]	<0.001		
								Beryllium Compounds	<0.001		

TABLE 3.1 - NORMALIZED RANKINGS OF CARCINOGENIC EFFECTS (CONTINUED)

Santa Clara Valley Integrated Environmental Management Project		Estimation and Evaluation of Cancer Risks From Air Pollution in the Minneapolis/St. Paul MSA		Urban Area Source Program		Development of Area Source Hazardous Air Pollutants Inventory: Chicago		Development of Area Source Hazardous Air Pollutants Inventory: Seattle - Tacoma	
Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score
Benzo(a)pyrene	0.321	Diesel PM	0.276	1,3-Butadiene	0.387	Chromium Compounds	0.201	1,3-Butadiene	0.407
Chromium (VI)	0.183	Gasoline PM	0.155	Ethylene Dichloride	0.193	Trichloroethylene	0.162	Chromium Compounds	0.262
Arsenic Compounds	0.138	Wood Stove PM	0.155	Polycyclic Organic Matter	0.124	Formaldehyde	0.159	Formaldehyde	0.128
Benzene	0.138	1,3-Butadiene	0.124	Chromium (VI)	0.048	Tetrachloroethylene	0.121	Benzene	0.103
Carbon Tetrachloride	0.092	Chromium (VI)	0.113	1,1,2,2-Tetrachloroethane	0.046	Benzene	0.113	Arsenic Compounds	0.026
Gasoline Vapors	0.046	Polycyclic Organic Matter	0.093	Vinyl Chloride	0.037	Ethylene Dichloride	0.111	Polycyclic Organic Matter	0.022
Cadmium Compounds	0.032	Benzene	0.041	Benzene	0.034	Methylene Chloride	0.030	Trichloromethylene	0.013
Nickel Compounds	0.014	Formaldehyde	0.041	Formaldehyde	0.025	Carbon Tetrachloride	0.023	Dioxins/Furans	0.010
Ethylene Oxide	0.014			Ethylene Dibromide	0.022	Chloroform	0.019	Tetrachloroethylene	0.010
Tetrachloroethylene	0.014			Acetaldehyde	0.018	Cadmium Compounds	0.015	Acetaldehyde	0.006
Methylene Chloride	0.005			Vinyl Bromide	0.016	Arsenic Compounds	0.014	Cadmium Compounds	0.004
Ethylene Dibromide	0.002			Acrylonitrile	0.016	Polycyclic Organic Matter	0.013	Beryllium Compounds	0.003
Beryllium Compounds	0.001			Hexachlorobutane	0.008	Dioxins/Furans	0.006	Methylene Chloride	0.003
Trichloroethylene	0.001			Arsenic Compounds	0.008	Vinyl Chloride	0.004	Methyl Chloride	<0.001
Chloroform	<0.001			Chloroform	0.006	Methyl Chloride	0.004	Styrene	<0.001
				1,1,2-Trichloroethane	0.006	1,3-Butadiene	0.003	Propylene Oxide	<0.001
				Vinylidene Chloride	0.004	Beryllium Compounds	0.001	Carbon Tetrachloride	<0.001
				Carbon Tetrachloride	0.003	Acrylonitrile	<0.001		
				Nickel Compounds	0.003	Propylene Oxide	<0.001		
				Cadmium Compounds	0.003	Styrene	<0.001		
				Dioxins/Furans	0.003	Asbestos	<0.001		
				Heptachlor	0.002				
				Naphthalene	0.002				
				Tetrachloroethylene	0.001				
				Bromoform	0.001				
				1,4-Dioxane	0.001				
				Methylene Chloride	0.001				
				PCBs	0.001				
				Chlordane	0.001				
				Methyl Chloride	0.001				
				Trichloroethylene	0.001				
				Benzo(a)pyrene	<0.001				
				Beryllium Compounds	<0.001				
				Hexachlorobenzene	<0.001				

1 PAHs = Polyaromatic Hydrocarbons
2 PCBs = Poly Chlorinated Biphenols
3 PICs = Products of Incomplete Combustion

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TABLE 3.2 - NORMALIZED RANKINGS OF NONCARCINOGENIC EFFECTS

Urban Air Toxics Assessment Project-Staten Island/New Jersey		HASTE		Connecticut		Arizona Hazardous Air Pollutant Research Program - Phoenix	
Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score
Benzene	0.389	Acrolein	0.903	Hydrochloric Acid	0.055	Acrolein	0.625
Chromium Compounds	0.233	Hydrogen Cyanide	0.054	Toluene	0.050	Manganese Compounds	0.118
Nickel Compounds	0.194	Acrylonitrile	0.016	Mercury compounds	0.049	Benzene	0.104
Carbon Tetrachloride	0.078	Glycol Ethers	0.009	Acetaldehyde	0.047	Barium Compounds	0.057
Formaldehyde	0.019	Ethylene Dibromide	0.007	Carbon Disulfide	0.046	Trimethylbenzene	0.048
Vanadium Compounds	0.019	Hydrochloric Acid	0.004	Sulfuric Oxide	0.046	Lead Compounds	0.014
Cadmium Compounds	0.019	Aniline	0.002	Lead Compounds	0.045	Trichloroethylene	0.011
Tetrachloroethylene	0.010	Hydrogen Sulfide	0.001	Xylene	0.044	Acetaldehyde	0.010
Manganese Compounds	0.008	Toluene	0.001	Ethylene	0.042	Tetrachloroethylene	0.007
Toluene	0.008	Hexane	0.001	Manganese Compounds	0.040	Ethylene Dibromide	0.002
Ethylbenzene	0.006	Propylene Dichloride	<0.001	Phenol	0.037	Chloroform	0.001
Lead Compounds	0.006	Acrylic Acid	<0.001	Methyl Alcohol	0.036	Formaldehyde	<0.001
Trichloroethylene	0.004	Styrene	<0.001	1,2-Dichloroethane	0.035	Cadmium Compounds	<0.001
Hexane	0.004	Epichlorohydrin	<0.001	Methyl Methacrylate	0.035	Acrylonitrile	<0.001
Chloroform	0.002	Methyl Isobutyl Ketone	<0.001	Acrolein	0.034	Arsenic Compounds	<0.001
Zinc Compounds	0.001	Manganese Compounds	<0.001	Propylene Oxide	0.034	Carbon Tetrachloride	<0.001
Mercury Compounds	<0.001	Chlorobenzene	<0.001	Hydrogen Fluoride	0.033	Methylene Dichloride	<0.001
Methylene Dichloride	<0.001	Propylene Oxide	<0.001	Acetone	0.031	p-Dichlorobenzene	<0.001
		Triethylamine	<0.001	Ethylene Glycol	0.031	Nickel Compounds	<0.001
		Dimethyl Formamide	<0.001	Methyl Ethyl Ketone	0.030	Chromium (VI)	<0.001
		Methyl Ethyl Ketone	<0.001	Ethyl Chloride	0.030		
		Ethylene Dichloride	<0.001	Chlorobenzene	0.029		
		Ethylbenzene	<0.001	Ethylbenzene	0.028		
		Methylene Chloride	<0.001	Isopropyl Alcohol	0.026		
		2-Nitropropane	<0.001	Methyl Isobutyl Ketone	0.026		
		Acetaldehyde	<0.001	Acetonitrile	0.023		
		p-Dichlorobenzene	<0.001	Nitrobenzene	0.021		
		Carbon Disulfide	<0.001	Zinc Compounds	0.016		
		Cumene	<0.001				
		1,2,4-Trichlorobenzene	<0.001				
		Mercury Compounds	<0.001				
		Vinyl Acetate	<0.001				
		Phthalic Anhydride	<0.001				
		Methyl-t-Butyl Ether	<0.001				
		Acetonitrile	<0.001				
		Ethyl Chloride	<0.001				
		1,2-Butylene Oxide	<0.001				
		Dichlorobenzene	<0.001				

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TABLE 3.2 -NORMALIZED RANKINGS OF NONCARCINOGENIC EFFECTS (CONTINUED)

Arizona Hazardous Air Pollutant Research Program - Tuscon		Arizona Hazardous Air Pollutant Research Program - Payson		Development of Area Source Hazardous Air Pollutants Inventory: Chicago		Development of Area Source Hazardous Air Pollutants Inventory: Seattle - Tacoma	
Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score	Pollutant	Normalized Score
Acrolein	0.633	Acrolein	0.581	Acrolein	0.736	Acrolein	0.840
Benzene	0.118	Benzene	0.197	Chloroform	0.058	Lead Compounds	0.042
Manganese Compounds	0.118	Manganese Compounds	0.103	Hydrogen Cyanide	0.047	Toluene	0.033
Barium Compounds	0.058	Barium Compounds	0.052	Toluene	0.044	Methyl Chloroform	0.020
Trimethylbenzene	0.026	Lead Compounds	0.020	Glycol Ethers	0.041	Hydrogen Cyanide	0.018
Lead Compounds	0.015	Acetaldehyde	0.018	Xylene	0.024	Glycol Ethers	0.012
Acetaldehyde	0.012	Trimethylbenzene	0.009	Hexane	0.012	Xylene	0.011
Toluene	0.007	Naphthalene	0.006	Hydrochloric Acid	0.011	Methyl Alcohol	0.006
Trichloroethylene	0.007	Toluene	0.005	Ethylene Glycol	0.006	Hexane	0.005
Tetrachloroethylene	0.006	Hexane	0.004	Methyl Ethyl Ketone	0.005	Hydrochloric Acid	0.004
Chloroform	0.001	Trichloroethylene	0.002	Lead Compounds	0.004	Methyl Ethyl Ketone	0.003
Formaldehyde	0.001	Tetrachloroethylene	0.001	,2,4-Trimethylpentane	0.004	2,2,4-Trimethylpentane	0.002
Cadmium Compounds	0.001	Cadmium Compounds	0.001	Mercury Compounds	0.003	Manganese Compounds	0.002
Arsenic Compounds	<0.001	Formaldehyde	0.001	Ethylbenzene	0.003	Ethylbenzene	0.001
Methylene Dichloride	<0.001	Arsenic Compounds	<0.001	Methyl Alcohol	0.001	Ethylene Glycol	0.001
Nickel Compounds	<0.001			Manganese Compounds	<0.001	Mercury Compounds	<0.001
p-Dichlorobenzene	<0.001					Methyl Isobutyl Ketone	<0.001
Carbon Tetrachloride	<0.001						

TABLE 3-3. RANKING OF POLLUTANTS BASED ON CARCINOGENIC EFFECTS ASSOCIATED WITH EMISSIONS FROM POINT, AREA AND MOBILE SOURCES

Pollutant	Rank	Normalized Scores											Sum of Scores
		Staten Island/New Jersey (1993)	Summary of Urban Air Toxics Risk Assessment Screening Studies - Five City	Summary of Urban Air Toxics Risk Assessment Screening Studies - Kanawha Valley	Summary of Urban Air Toxics Risk Assessment Screening Studies - South East Chicago	Transboundary Air Toxics Study	Arizona Hazardous Air Pollutant Research Program - Phoenix	Arizona Hazardous Air Pollutant Research Program - Tuscon	Summary of Urban Air Toxics Risk Assessment Screening Studies - Southwest Chicago	Summary of Urban Air Toxics Risk Assessment Screening Studies - Baltimore	Santa Clara Valley Integrated Environmental Management Project	Urban Area Source Program	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tetrachloroethylene	19	8.13E-03	5.58E-03	1.73E-03	3.11E-04	5.36E-04	3.20E-03	2.47E-03	3.24E-03	1.46E-02	1.38E-02	1.42E-03	5.50E-02
1,1,2,2-Tetrachloroethane	20											4.59E-02	4.59E-02
Trichloroethylene	21	6.51E-03	1.66E-03	5.76E-04	2.49E-03	8.05E-04	8.80E-03	5.19E-03	3.24E-03	9.73E-03	9.17E-04	5.74E-04	4.07E-02
Vinyl Chloride	22		1.49E-04			1.07E-03	1.24E-03		6.47E-04			3.67E-02	3.98E-02
Dioxins	23				1.24E-04	3.22E-02			9.71E-04			2.75E-03	3.80E-02
Ethylene Dibromide	24			5.76E-04	6.22E-04	1.61E-03	2.18E-03		3.24E-04	1.46E-03	1.83E-03	2.23E-02	3.09E-02
Acetaldehyde	25						4.73E-03	4.94E-03				1.81E-02	2.78E-02
p-Dichlorobenzene	26						1.32E-02	1.06E-02					2.36E-02
Beryllium compounds	27					1.56E-02			2.91E-07		1.38E-03	2.75E-04	1.72E-02
Asbestos	28					1.53E-02			1.62E-03				1.69E-02

TABLE 3-3. RANKING OF POLLUTANTS BASED ON CARCINOGENIC EFFECTS ASSOCIATED WITH EMISSIONS FROM POINT, AREA AND MOBILE SOURCES (CONTINUED)

Pollutant	Rank	Normalized Scores											
		Staten Island/New Jersey (1993)	Summary of Urban Air Toxics Risk Assessment Screening Studies - Five City	Summary of Urban Air Toxics Risk Assessment Screening Studies - Kanawha Valley	Summary of Urban Air Toxics Risk Assessment Screening Studies - South East Chicago	Transboundary Air Toxics Study	Arizona Hazardous Air Pollutant Research Program - Phoenix	Arizona Hazardous Air Pollutant Research Program - Tucson	Summary of Urban Air Toxics Risk Assessment Screening Studies - Southwest Chicago	Summary of Urban Air Toxics Risk Assessment Screening Studies - Baltimore	Santa Clara Valley Integrated Environmental Management Project	Urban Area Source Program	Sum of Scores
Vinyl Bromide	29											1.61E-02	1.61E-02
Hexachlorobutane	30											8.03E-03	8.03E-03
Hexachlorobenzene	31								6.47E-03			2.00E-04	6.67E-03
Vinylidene Chloride	32			5.76E-04					1.94E-04			4.13E-03	4.90E-03
1,1,2-Trichloroethane	33											4.13E-03	4.13E-03
Heptachlor	34					3.83E-05						2.07E-03	2.10E-03
Naphthalene	35											1.58E-03	1.58E-03
PCBs	36					2.68E-04			1.29E-06			1.08E-03	1.35E-03
Bromoform	37											1.31E-03	1.31E-03
1,4-Dioxane	38											1.15E-03	1.15E-03
Chlordane	39					3.83E-05						1.01E-03	1.05E-03
Methyl Chloride	40								6.47E-05			7.12E-04	7.76E-04
Styrene	41					2.68E-04			1.94E-05				2.88E-04
Epichlorohydrin	42					3.83E-05			3.24E-06				4.15E-05
Acrylamide	43								3.24E-06				3.24E-06
Propylene Oxide	44								2.27E-06				2.27E-06

TABLE 3-4. RANKING OF POLLUTANTS BASED ON NON-CARCINOGENIC EFFECTS ASSOCIATED WITH EMISSIONS FROM POINT, AREA, AND MOBILE SOURCES

Pollutant	Rank	Normalized Scores			Sum of Scores
		Arizona Hazardous Air Pollutant Research Program - Phoenix	Arizona Hazardous Air Pollutant Research Program - Tuscon	Staten Island/New Jersey	
Acrolein	[illegible]	6.25E-01	6.33E-01	[illegible]	[illegible]
Benzene	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Manganese compounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chromium compounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nickel compounds	[illegible]	5.03E-05	5.62E-05	[illegible]	[illegible]
Barium compounds	[illegible]	[illegible]	5.79E-02	[illegible]	[illegible]
Carbon Tetrachloride	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trimethylbenzene	[illegible]	4.85E-02	2.59E-02	[illegible]	[illegible]
Hexane	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lead compounds	10	1.35E-02	1.50E-02	5.63E-03	[illegible]
Acetaldehyde	11	1.04E-02	1.16E-02		2.20E-02
Tetrachloroethylene	12	6.74E-03	5.76E-03	9.39E-03	2.19E-02
Trichloroethylene	13	1.05E-02	6.71E-03	3.76E-03	2.10E-02
Formaldehyde	14	5.00E-04	5.28E-04	1.88E-02	1.98E-02
Cadmium compounds	15	4.97E-04	5.17E-04	1.88E-02	1.98E-02
Vanadium compounds	16			1.88E-02	1.88E-02
Toluene	17		7.49E-03	7.51E-03	1.50E-02
Ethylbenzene	18			5.63E-03	5.63E-03
Chloroform	19	1.45E-03	8.99E-04	1.69E-03	4.04E-03
Ethylene Dibromide	20	2.14E-03			2.14E-03
Arsenic compounds	21	3.49E-04	4.04E-04		7.53E-04
Zinc compounds	22			5.63E-04	5.63E-04
Acrylonitrile	23	4.72E-04			4.72E-04
Mercury compounds	24			3.76E-04	3.76E-04
Methylene Dichloride	25	1.19E-04	8.99E-05	1.50E-04	3.60E-04
p-Dichlorobenzene	26	6.60E-05	5.62E-05		1.22E-04
Chrome-VI	27	3.14E-06			3.14E-06

TABLE 3-5. RANKING OF POLLUTANTS BASED ON CARCINOGENIC EFFECTS ASSOCIATED WITH EMISSIONS FROM URBAN AREA SOURCES

Pollutant	Rank	Normalized Scores			Sum of Scores
		Haste Project	Chicago Area	Puget Sound	
1,3-Butadiene	[illegible]	5.53E-02	[illegible]	[illegible]	[illegible]
Chromium compounds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vinyl Chloride	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Formaldehyde	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Benzene	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Acrylonitrile	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2-Nitropropane	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trichloroethylene	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tetrachloroethylene	[illegible]	[illegible]	[illegible]	1.00E-02	[illegible]
Ethylene Dichloride	[illegible]	1.84E-02	[illegible]	[illegible]	[illegible]
Arsenic compounds	11	9.21E-04	1.44E-02	2.63E-02	4.17E-02
Methylene Chloride	12	5.53E-03	3.02E-02	2.88E-03	3.86E-02
Ethylene Dibromide	13	3.68E-02			3.68E-02
Ethylene Oxide	14	3.68E-02			3.68E-02
POM	15		1.27E-02	2.23E-02	3.50E-02
Cadmium compounds	16	1.47E-02	1.51E-02	4.01E-03	3.38E-02
Carbon Tetrachloride	17	7.37E-03	2.30E-02	4.80E-05	3.04E-02
Chloroform	18	7.37E-03	1.86E-02		2.60E-02
1,1,2,2-Tetrachloroethane	19	1.66E-02			1.66E-02
Dioxins/furans	20		5.65E-03	1.03E-02	1.59E-02
Vinylidene Chloride	21	9.21E-03			9.21E-03
Acetaldehyde	22	3.68E-05		6.40E-03	6.44E-03
Beryllium compounds	23	1.84E-04	1.29E-03	3.00E-03	4.48E-03
Methyl Chloride	24	1.84E-04	3.75E-03	3.25E-04	4.26E-03
1,1,2-Trichloroethane	25	1.84E-03			1.84E-03
Propylene Oxide	26	9.21E-04	3.99E-04	8.54E-05	1.41E-03
Dioxins	27	7.37E-04			7.37E-04
Styrene	28		2.05E-04	2.99E-04	5.05E-04
Nickel compounds	29	3.68E-04			3.68E-04
Asbestos	30		5.59E-05		5.59E-05
Epichlorohydrin	31	1.84E-05			1.84E-05

TABLE 3-6. RANKING OF POLLUTANTS BASED ON NON-CARCINOGENIC EFFECTS ASSOCIATED WITH EMISSIONS FROM URBAN AREA SOURCES

Pollutant	Rank	Normalized Scores			Sum of Scores
		Haste Project	Chicago Area	Puget Sound	
[redacted]					
Methyl Chloroform	8			1.97E-02	1.97E-02
Hydrochloric Acid	9	3.61E-03	1.11E-02	3.85E-03	1.86E-02
Hexane	10	5.42E-04	1.19E-02	4.75E-03	1.72E-02
Acrylonitrile	11	1.63E-02			1.63E-02
Methyl Ethyl Ketone	12	5.42E-05	4.86E-03	2.99E-03	7.90E-03
Methyl Alcohol	13		1.47E-03	6.26E-03	7.73E-03
Ethylene Dibromide	14	7.23E-03			7.23E-03
Ethylene Glycol	15		5.96E-03	1.09E-03	7.05E-03
2,2,4-Trimethylpentane	16		4.06E-03	2.12E-03	6.18E-03
Ethylbenzene	17	3.61E-05	2.89E-03	1.13E-03	4.06E-03
Mercury compounds	18	3.61E-06	2.97E-03	4.82E-04	3.46E-03
Aniline	19	1.81E-03			1.81E-03
Manganese compounds	20	1.08E-04	1.20E-05	1.62E-03	1.74E-03
Hydrogen Sulfide	21	1.45E-03			1.45E-03
Methyl Isobutyl Ketone	22	1.26E-04		3.49E-04	4.76E-04
Propylene Dichloride	23	3.61E-04			3.61E-04
Acrylic Acid	24	1.81E-04			1.81E-04
Styrene	25	1.81E-04			1.81E-04
Epichlorohydrin	26	1.45E-04			1.45E-04
Chlorobenzene	27	9.03E-05			9.03E-05
Propylene Oxide	28	9.03E-05			9.03E-05
Triethylamine	29	7.23E-05			7.23E-05
Dimethyl Formamide	30	5.42E-05			5.42E-05
2-Nitropropane	31	3.61E-05			3.61E-05
Methylene Dichloride	32	3.61E-05			3.61E-05
Vinylidene Chloride	33	3.61E-05			3.61E-05
Acetaldehyde	34	1.81E-05			1.81E-05
p-Dichlorobenzene	35	1.81E-05			1.81E-05
Carbon Disulfide	36	9.03E-06			9.03E-06
Cumene	37	9.03E-06			9.03E-06
1,2,4-Trichlorobenzene	38	5.42E-06			5.42E-06
Vinyl Acetate	39	3.61E-06			3.61E-06
Phthalic Anhydride	40	1.81E-06			1.81E-06
Methyl-t-Butyl Ether	41	1.45E-06			1.45E-06
Acetonitrile	42	7.23E-07			7.23E-07
Chloroethane	43	7.23E-07			7.23E-07
1,2-Butylene Oxide	44	1.08E-07			1.08E-07
Dichlorobenzene	45	1.81E-08			1.81E-08

Figure 3.1. Rankings of Aggregate Normalized Carcinogenic Scores: Point, Area, and Mobile Sources

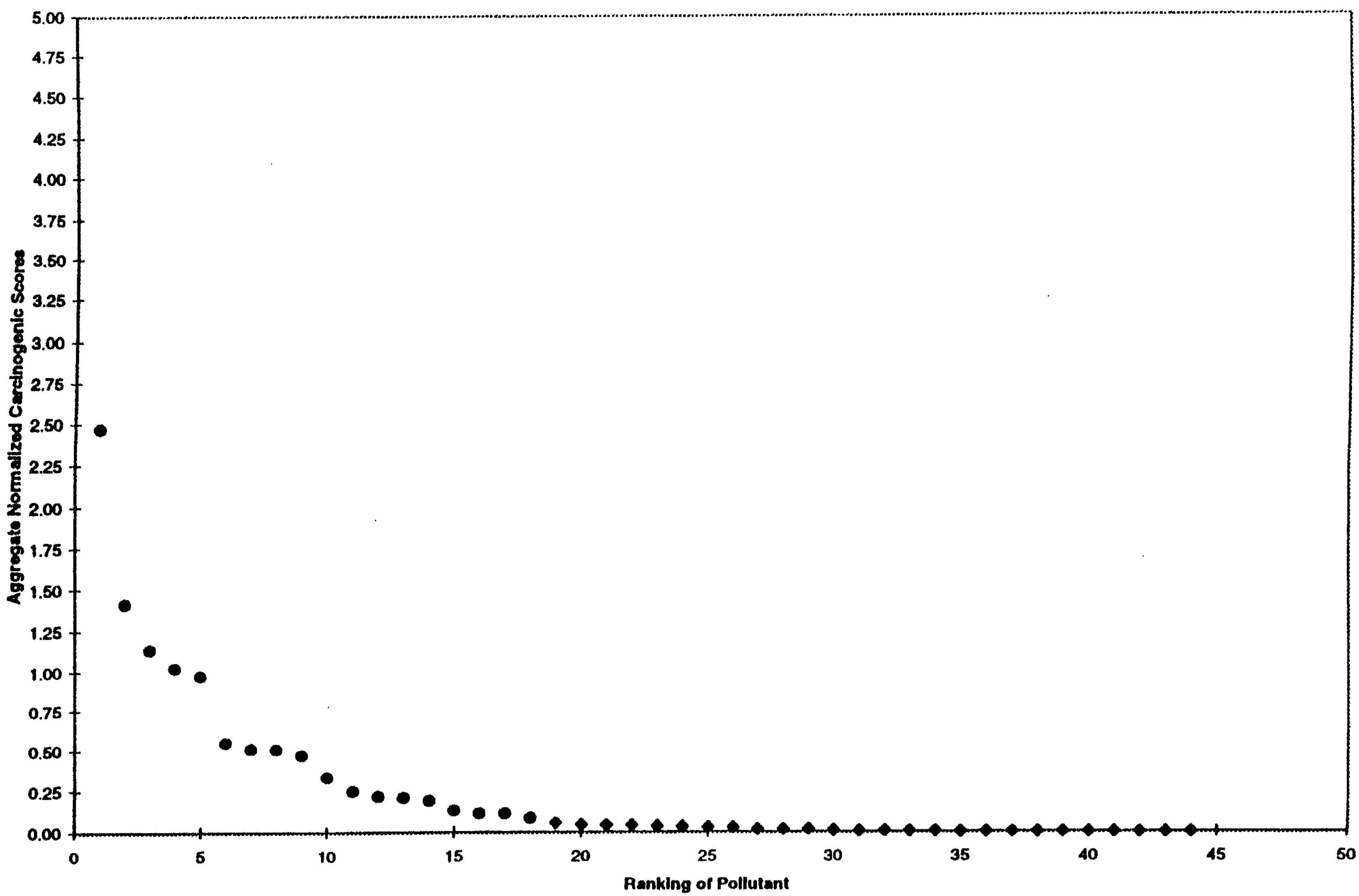


Figure 3.2. Rankings of Aggregate Normalized Noncarcinogenic Score: Point, Area, and Mobile Sources

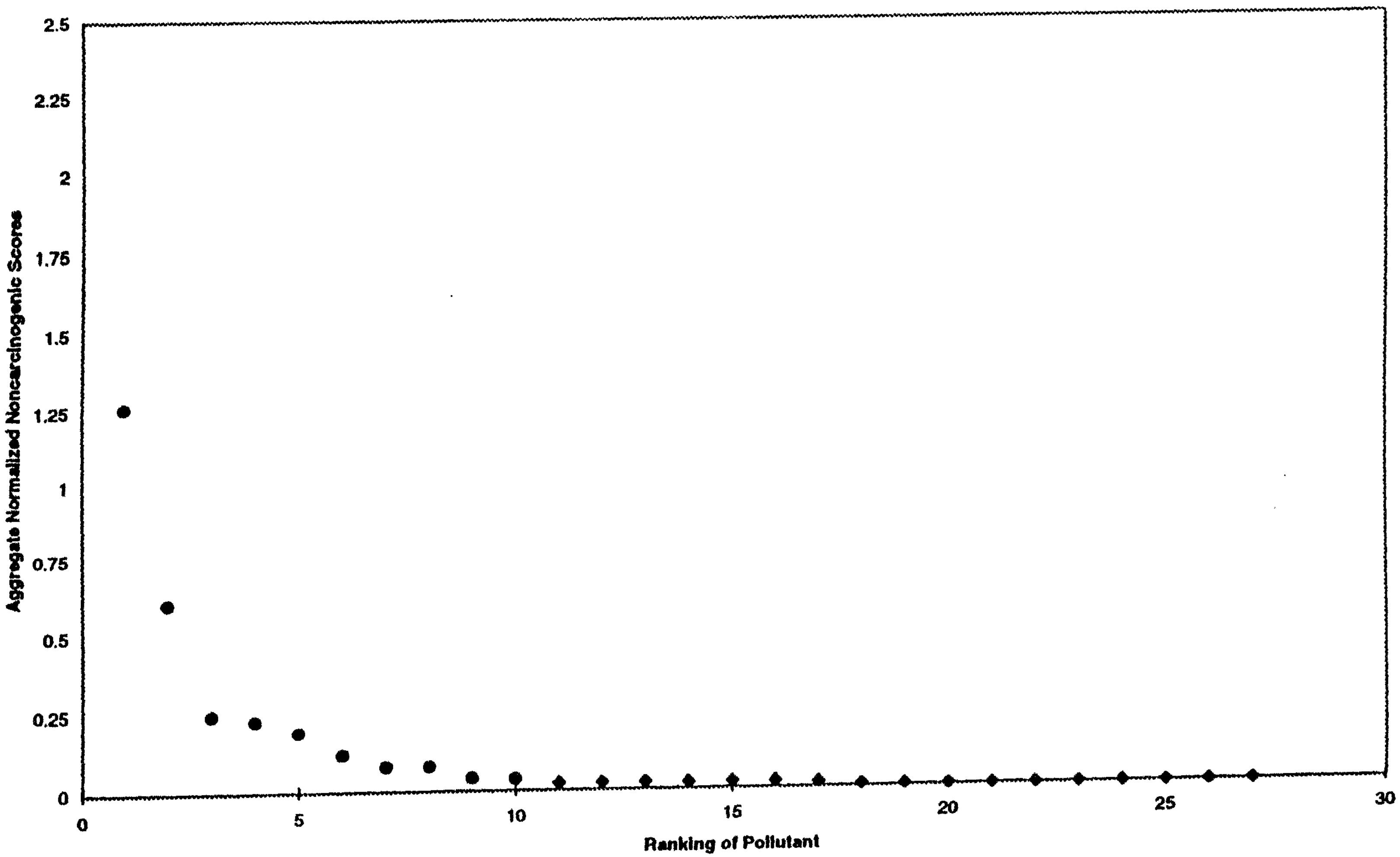


Figure 3.3. Rankings of Aggregate Normalized Carcinogenic Scores: Area Sources

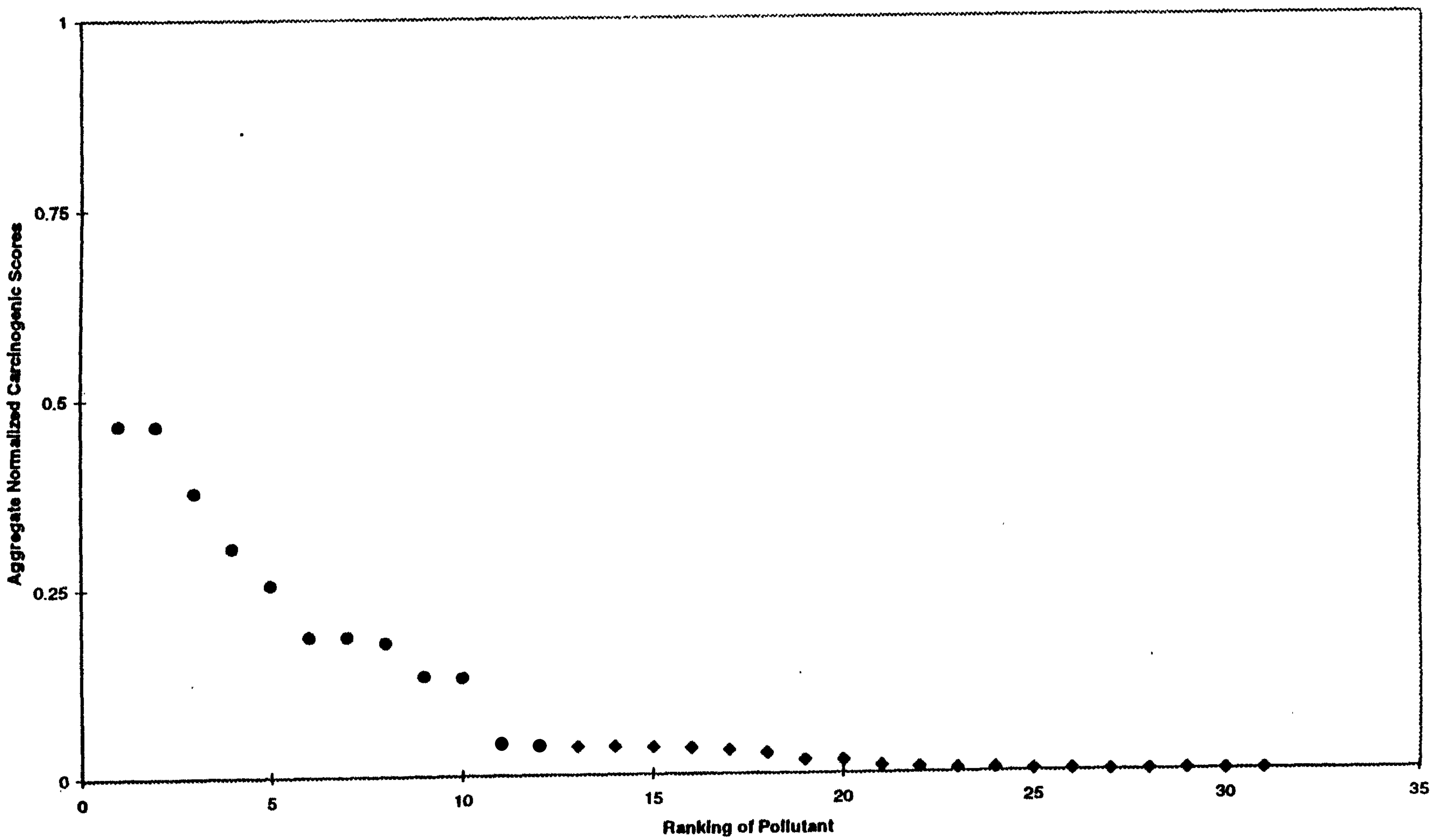
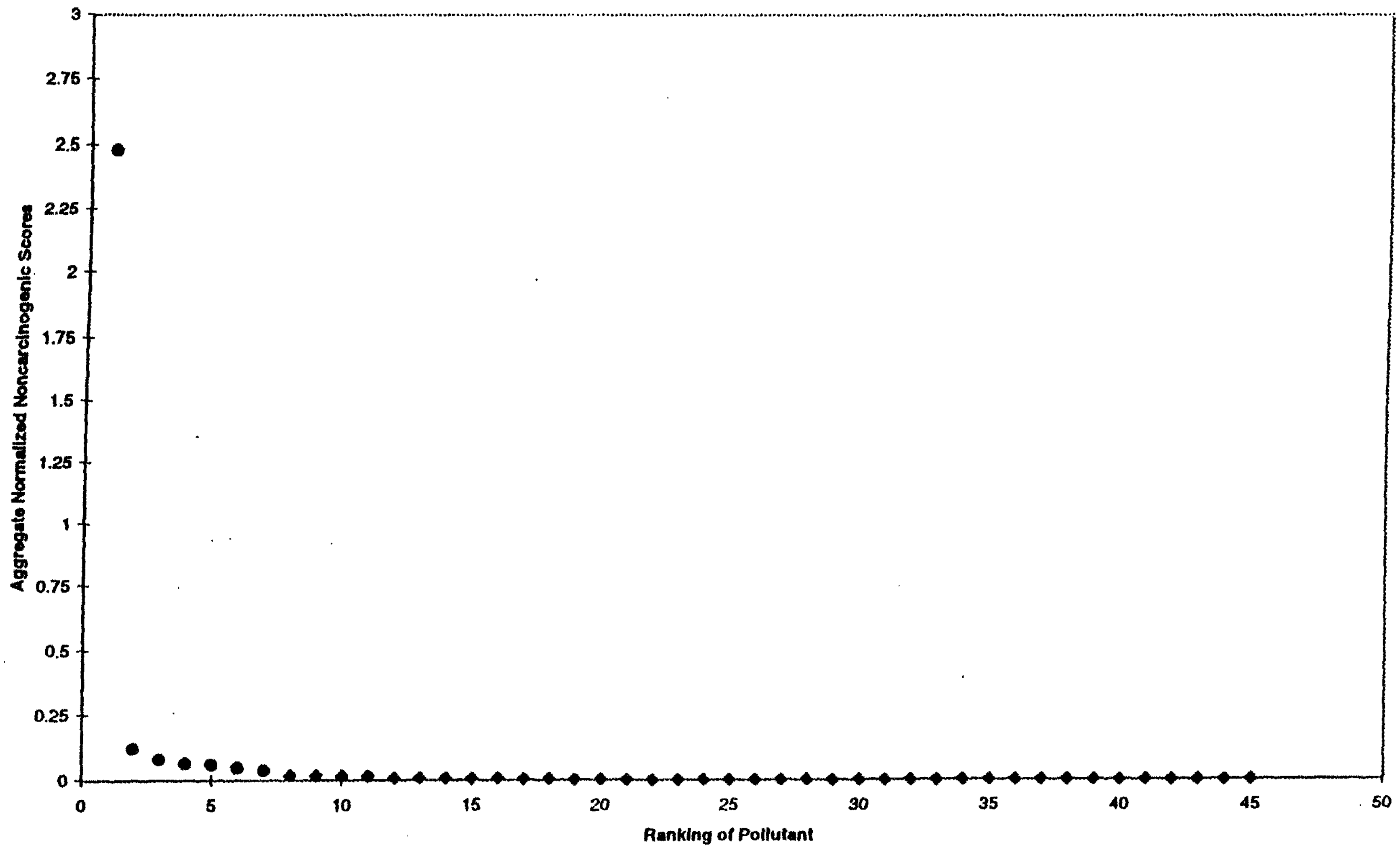


Figure 3.4. Rankings of Aggregate Normalized Noncarcinogenic Scores: Area Sources



APPENDIX B:

Modeled Outdoor Concentrations of Hazardous Air Pollutants: Analysis of Data from the Cumulative Exposure Project for the Urban Area Source Program

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Office of Policy, Planning and Evaluation

Office of Air Quality Planning and Standards

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CONTENTS

1 INTRODUCTION

In order to gain an expanded understanding of the national distribution of air toxics concentrations, EPA's Office of Policy, Planning and Evaluation has conducted a national air toxics modeling study as part of its Cumulative Exposure Project. Outdoor concentrations of 148 air toxics were modeled at the census tract level for the entire continental U.S., in both urban and rural areas. To evaluate the potential impacts of air toxics in urban areas, modeled concentrations were compared with potential regulatory thresholds of concern or "benchmark concentrations." Modeled concentrations greater than these benchmark concentrations provide an indication of a potential health risk to the general population. The frequency and magnitude of modeled concentrations greater than benchmark concentrations provide an indication of those hazardous air pollutants having the greatest potential to pose health risks to the general population.

This chapter presents the methods for and results of this screening-level study of national urban air toxics concentrations. In addition, results for urban areas are compared with those for rural areas. Contributions of area sources of emissions, relative to point sources and mobile sources, are also assessed.

2 METHODS

There are three primary components to this analysis of urban air toxics:

1. Estimating Air Toxics Emissions and Modeling Air Toxics Concentrations
2. Identifying Benchmark Concentrations

3. Comparing Modeled Concentrations to Benchmark Concentrations.

The methods used in each of these components are discussed below.

2.1 Estimating Air Toxics Emissions and Modeling Air Toxics Concentrations

2.1.1 Atmospheric Modeling Methodology

To meet this study's objectives of estimating long-term concentrations of HAPs on a national scale with reasonable geographic resolution, a long-term Gaussian dispersion modeling approach was selected. The Assessment System for Population Exposure Nationwide (ASPEN) used in this study is a modified version of EPA's Human Exposure Model (HEM). The HEM is a standard modeling tool used by EPA staff to support regulatory activity and special studies, such as EPA's electric utility study (U.S. Environmental Protection Agency 1996d). The HEM utilizes a Gaussian dispersion modeling approach for point sources with optional first-order decay and a simple deposition algorithm. For this study, the deposition algorithm has been improved and treatment of area and mobile source emissions has been modified. In addition, methods to estimate secondary formation of seven HAPs (formaldehyde, acetaldehyde, propionaldehyde, methyl ethyl ketone, acrolein, phosgene, and cresol) have been incorporated.

For each source, the model calculates ground-level concentrations as a function of radial distance and direction from the source for a set of receptors laid out in a radial grid pattern. These concentrations represent the steady-state concentrations that would occur with constant emissions and meteorological parameters, and are calculated for model receptor locations up to 50 kilometers (km) from each source. Concentrations resulting from any number of sources are extrapolated from model receptor locations to the centroids of population subdivisions, such as census tracts, block groups, or blocks. The model may be used to simulate any size modeling domain for which appropriate data are available.

In recognition of the potential for a large degree of spatial variation in ambient concentrations, geographic resolution at the census tract level was selected for this study. There are approximately 60,000 census tracts in the continental United States. Census tracts generally contain roughly equal populations, and therefore tend to be smaller in urban areas and larger in rural areas. This level of resolution focuses greater computing resources in urban locations, and appropriately balances the desire for high spatial resolution against the limitations of the model and the available emissions and meteorological databases that preclude accurate modeling at higher resolution. The modeled concentrations approximate the population-weighted average of outdoor HAP concentrations experienced within a census tract over the course of a year.

Modeling was conducted separately for each source category group identified in the following section. For each HAP, the modeled concentrations for each category group, along with the background concentrations identified below, were summed together to arrive at a modeled concentration for each census tract. Details of the ASPEN model are found in Chapter 5 of the technical report on the modeling portion of this study (Rosenbaum et al. 1998).

2.1.2 Emissions Inventory

2.1.2.1 Emissions categories and data sources

HAPs are emitted from a variety of sources, including large manufacturing facilities such as chemical production plants, combustion facilities such as waste incinerators, small commercial operations such as dry cleaners, and both onroad and nonroad mobile sources. For this analysis, sources of HAP emissions were aggregated into six source category groups:

- manufacturing point sources (e.g., chemical manufacturing, refineries, primary metals)
- nonmanufacturing point sources (e.g., electric utility generators, municipal waste combustors)
- manufacturing area sources (e.g., wood products manufacturing, degreasing)
- nonmanufacturing area sources (e.g., dry cleaning, consumer products, small medical waste incinerators)
- onroad mobile sources (e.g., cars, buses, trucks)
- nonroad mobile sources (e.g., farm equipment, airplanes, boats).

In this study, emissions from manufacturing point sources are represented by data from EPA's 1990 Toxics Release Inventory (TRI) (U.S. Environmental Protection Agency 1991). TRI is an annual compilation of facility-reported estimates of releases and transfers for over 300 pollutants. TRI is a comprehensive database of estimated emissions for large manufacturing sources, but does not address many important sources of toxics emissions, including mobile sources, combustion sources such as incinerators, and small industrial, commercial, consumer and agricultural sources (i.e. area sources). For these other source category groups, this study estimates HAP emissions from EPA's extensive 1990 base year national emissions inventories for volatile organic compounds (VOCs) and particulate matter (PM) (Pechan 1994; U.S. Environmental Protection Agency 1993b). These inventories contain facility-specific data on point sources and county-level emissions totals for mobile sources and area sources.

HAP emissions estimates are derived from VOC and PM emission estimates through the application of speciation profiles. Speciation profiles are industry-specific and/or process-specific estimates of the presence of particular chemical constituents in a VOC or PM emissions stream. For example, estimates of gaseous HAP emissions from automobile refinishing operations can be derived by combining the estimated total VOC emissions from automobile refinishing with a speciation profile, which provides estimates of the percentage of automobile refinishing VOC emissions made up of individual chemical constituents, such as benzene and toluene. Speciation profiles are available from EPA's SPECIATE database (U.S. Environmental Protection Agency 1992) and from the technical literature (Battye and Williams 1994; Burnet et al. 1990; California Air Resources Board 1991; Edgerton et al. 1985; Hare and White 1991; Harley and Cass 1994; Harley et al. 1992; Hildemann et al. 1991; Ingalls 1991; Lipari et al. 1984; Miller et al. 1994; Sagebiel et al. 1996; Scheff et al. 1992; Scheff et al. 1994; U.S. Environmental Protection Agency 1989; U.S. Environmental Protection Agency 1996d). Speciation profiles are not available for all source categories; for categories without profiles, emissions are estimated using profiles for source categories judged to be similar. This introduces some uncertainty into the characterization of emissions. However, it is necessary to use estimates with uncertainties in order to approximate actual HAP concentrations, since many sources and source categories have not been characterized in detail. To omit such sources could result in significant underestimates of HAP concentrations.

In this analysis, the definition of an area source is not precisely equivalent to the CAA Section 112 definition, nor is the definition of a point source precisely equivalent to the CAA section 112 definition of a major source. Area source emissions in this analysis are derived from EPA's national inventories of VOC and PM emissions. In these inventories, area sources are defined as those that do not emit more than 100 tons per year of any criteria pollutant (VOCs, PM, carbon monoxide, nitrogen oxides, or sulfur dioxide). Some of the emissions in this analysis attributed to area sources may actually be emitted by facilities which are defined as major sources under CAA section 112—that is, facilities which emit more than 10 tons per year of any single HAP or 25 tons per year of any combination of HAPs. There also may be facilities classified as point sources in this analysis which are considered area sources under CAA section 112. The potential implications of these different definitions of area sources are discussed in Section 4 below.

The scope of the modeling exercise was limited to a certain extent by the available emissions data. The domain for the modeling exercise is comprised of the continental

United States. The national VOC and PM inventories used to develop much of the HAP emissions estimates for this study do not include data for Alaska or Hawaii; these states were therefore not included in the modeling study. In addition, 148 out of the 188 HAPs listed in CAA section 112(b)(1) are included in the modeling study. There were no emissions data identified for the remaining HAPs in the data sources used.[1]

2.1.2.2 Spatial Allocation

For point sources, emissions data are available for specific facility locations. All emissions data for area sources and mobile sources, however, are estimated as county totals. Before HAP emissions derived from these inventories can be used effectively in dispersion modeling, they should be allocated to smaller geographic units within the counties to approximate the spatial distribution of actual emissions.

To allocate emissions from the county level to the census tract level, 20 different surrogates were developed, as shown in Table 1. Each surrogate is based on data available at the census tract level, and represents an approximation of the distribution of emissions-generating activities across the census tracts within a county for at least one area source or mobile source category of emissions. Surrogates were developed using data on population (Bureau of the Census 1990a; Bureau of the Census 1990b), roadway miles and railway miles (Bureau of the Census 1993), and land use (U.S. Geological Survey various dates) for each census tract. For each area source and mobile source

[1] A few HAPs with available emissions data, such as chlorine and titanium tetrachloride, were not included in the modeling exercise because of their physical/chemical properties which make dispersion modeling

category. county emissions were allocated to constituent census tracts in proportion to the fraction of the total county value of the corresponding surrogate. For example, each county's emissions from lawn and garden equipment are allocated to each census tract in proportion to the tract's percentage of residential land area within the county, while emissions from industrial sources are allocated in proportion to industrial land use, and mobile source emissions are allocated using data on population and roadway miles in each tract.

2.1.3 Background Concentrations

The emissions inventory and modeling methodologies described above are used to estimate long-term outdoor concentrations of HAPs attributable to 1990 anthropogenic emissions, within 50 kilometers of each source. For many HAPs, however, outdoor concentrations may include "background" components attributable to long-range transport, re-suspension of historical emissions, and non-anthropogenic sources. To accurately estimate 1990 outdoor concentrations of HAPs, it is necessary to account for these background concentrations which are not represented by atmospheric modeling of 1990 anthropogenic emissions.

In this study, background concentrations are represented by inclusion of concentration values measured at "clean air locations" remote from the impact of local anthropogenic sources. Background concentrations were identified from the literature (Grosjean 1991; Howard 1989; Howard 1990; Howard 1991; Howard 1992; Howard 1997; Khalil and

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difficult.

Rasmussen 1984; Panshin and Hites 1994a; Panshin and Hites 1994b; Singh et al. 1985; U.S. Environmental Protection Agency 1994a; U.S. Environmental Protection Agency 1996c; Wiedmann et al. 1994; World Meteorological Organization 1991) for 28 HAPs, and are shown in Table 2. These values were obtained from measurement studies characterized as rural/remote, hemispheric baseline, remote ocean, global background, or other terms denoting contributions from only natural sources or long-range transport. For these HAPs, the estimated concentration in each census tract is determined by the summing together the estimated background concentrations and the modeled concentrations arising from 1990 emissions. Background concentrations are assumed to be constant across all census tracts; the available data are insufficient to address any possible geographic variations in background. Because no background concentration values were identified in the technical literature for other 120 HAPs included in this study, their background concentrations are assumed to be zero. This may result in underestimation of outdoor concentrations for some HAPs.

2.1.4 Evaluation of Modeled Concentrations

Performance of the model was evaluated by comparing modeled concentrations of HAPs to available monitored concentrations. In addition, modeled and monitored carbon monoxide (CO) concentrations were also compared for evaluation of model performance. Although CO is not a HAP, it was included in the model simulations specifically for model evaluation purposes, because the CO measurement data base contains significantly more monitoring sites than the HAP measurement data base. In terms of dispersion and other atmospheric processes after release, CO is expected to behave similarly to gaseous

HAPs with very low reactive decay rates. In addition, CO is measured hourly throughout the year, whereas HAP measurements are typically 24-hour averages taken approximately every twelfth day. The greater temporal coverage reduces uncertainty in annual average statistics, and allows for time-of-day comparisons.

2.1.4.1 Monitoring Data Sets

Quantitative comparisons of 1990 annual average ASPEN model predictions with observed HAP concentrations were made for several monitoring programs summarized in Table 3. Some of the programs were not operating in 1990, so measurements for other years between 1988 and 1992 were used in some cases, introducing some uncertainty into the comparisons.

HAP measurement data from the monitoring programs identified in the table were not used for the quantitative model performance evaluation in any cases where more than 10 percent of the measurements were below the minimum detection levels (MDLs). The uncertainty in estimating an annual average concentration from monitoring data sets with large numbers of non-detects limits the usefulness of such data sets in quantitative model performance evaluation. More qualitative analysis of some of these data sets was used to supplement the information from the quantitative model performance evaluation. For data sets used in the quantitative analysis, those values below the MDL were set equal to half the detection limit as a default in calculating annual average concentrations.

CO data from 259 monitoring sites were extracted from EPA's Aerometric Information Retrieval System (AIRS) for comparison with ASPEN predictions. In selecting the sites, an attempt was made to eliminate those monitors identified as microscale or middle-scale and/or as maximum concentration or source-oriented. Because these monitors are located in order to detect extreme concentrations, or "hot spots", they are likely to record concentrations that are significantly higher than the ASPEN estimates for the corresponding census tracts, which represent tract averages. However, not all monitor records contained these identifiers, and some are likely to be incorrectly identified. Therefore, a certain amount of underprediction of CO concentrations for this set of 259 monitor locations is expected. A separate analysis was conducted for the 100 CO monitors out of the set of 259 that were specifically designated as representative of neighborhood scale (0.5 to 4 km), urban scale (4 to 50 km), or regional scale (more than 50 km). Comparison of model outputs with measured concentrations from this subset of monitors provides an analysis that is not influenced by any unidentified "hot spot" monitors included in the larger set of 259.

2.1.4.2 Evaluation Methods

For each HAP at each monitoring location with a full year of data and fewer than 10 percent of observations below the MDL, the ratio of the predicted (modeled) concentration to the observed (monitored) concentration was calculated. In order to account for the possibility that a pollutant monitor may be nearly equidistant from multiple census tract centroids, measured concentrations were compared with a distance-weighted average of the nearest six tract concentration predictions, weighting each centroid value by 1/distance^2. Note that the ASPEN algorithms are designed to estimate concentrations that represent the average throughout the census tract. Although the monitored HAP values are point measurements, they are typically made in locations where concentration gradients are not expected to be steep, because the long-term monitoring programs from which they are taken are intended to represent general population exposures. Sensitivity analysis showed that results are not substantially different when only the closest census tract is used for comparison.

The same evaluation methods were also used for the CO model-monitor comparisons. An assumed CO background concentration of 125 ppb (144 $\mu g/m^3$) was added to the sum of predicted anthropogenic contributions to CO concentrations for this comparison. This value is based on 1989-1990 measurements at Niwot Ridge, Colorado (Novelli et al. 1992), a remote land site at approximately intermediate U.S. latitude (40N).

2.2 Benchmark Concentrations

Toxicological information on health effects and dose-response relationships for the 148 hazardous air pollutants included in this study was assembled from a variety of sources, evaluated comparatively, and assigned to a series of tiers defined by quality and availability of information, and consistency of methodology. Much of the needed health effects information was previously compiled for EPA's proposed rulemaking under the authority of section 112(g) of the Clean Air Act. For this study, the 112(g) information was updated, and information from several additional data sources was incorporated (Caldwell et al. 1998).

Hazard information and dose-response data for the HAPs were used to develop benchmark concentrations for carcinogenic hazard and for noncarcinogenic hazard from both long-term and short-term exposure. For each hazard category, a benchmark concentration representing a presumptive health protective value was selected. For carcinogenic hazard, the benchmark was selected to be the concentration of a known, probable, or possible human carcinogen representing an upper bound one-in-one-million excess probability of contracting cancer over a lifetime of exposure. The selection of this benchmark is based on provisions of CAA sections 112(c)(9) and 112(f) that allow source categories to be exempted from regulation when posing less than a one-in-one-million lifetime cancer risk to the most exposed individual.

For noncarcinogenic hazards, the benchmark was selected to be the concentration of a HAP likely to be without appreciable risk of noncancer effects from long-term or short-term exposures. This benchmark is based on the provision of section 112(f) of the CAA requiring "residual risk" emissions standards to "provide an ample margin of safety to protect public health" from non-cancer effects. Similar language is also found in CAA section 112(c)(9). EPA inhalation reference concentrations (RfCs), or similar values developed by other agencies, representing levels below which long-term exposure is not expected to result in any adverse health effects, were selected as the benchmark concentrations for non-cancer health effects from long-term exposure.

Benchmark concentrations for potential non-cancer hazards from short-term exposures to HAPs were developed using EPA's Levels of Concern (LOC). LOCs are established for chemicals on the Superfund Amendments and Reauthorization Act section 302 list of "extremely hazardous substances" (U.S. Environmental Protection Agency et al. 1987). LOCs are airborne concentrations of chemicals for which no serious irreversible health effects are expected to occur following a short-term exposure of 30 minutes. To derive a short-term benchmark concentration, the LOC was divided by a safety factor of 1000 to address the fact that the LOC is based on lethality as an endpoint and to address the uncertainty in the derivation of the LOC.

Wherever available, EPA estimates of inhalation unit risks (IURs) for cancer and EPA reference concentrations (RfCs) for non-cancer effects were used in developing benchmark concentrations. When these values were not available, other available values were used as benchmark concentrations, including: EPA estimates of cancer risks from oral exposure, converted into inhalation units; California EPA inhalation unit risks and Reference Exposure Levels (RELs); and Minimal Risk Levels (MRLs) developed by the Agency for Toxic Substances and Disease Registry (ATSDR).

Fourteen of the 148 HAPs included in this study are chemical groups. It is difficult to assess the toxicity of chemical groups because each is comprised of a number of different constituents that may have varying levels of toxicity. For this analysis, toxicity values that can be assigned to an entire chemical group are included (Caldwell et al. 1998). Toxicity values applicable only to individual constituents of chemical groups are not included, because the modeled concentrations developed in this study represent the entire group.

The various benchmark concentrations were grouped into tiers to account for differences in methodology, inherent uncertainty of data used in derivation, and level of peer review. Tier I includes values derived from EPA IURs and RfCs, and represents those values with the most consistency in derivation and highest level of peer review. Tier II includes other categories of EPA data, as well as quantitative information from California EPA and ATSDR.

2.3 Comparison of Modeled Concentrations to Benchmark Concentrations

This study's modeled concentrations are estimates of annual average outdoor HAP concentrations for 1990. To screen for whether a modeled concentration represents a potential health risk, it is compared to benchmark concentrations for cancer and chronic noncancer effects, assuming long-term exposure. These benchmark concentrations represent an estimated concentration at which a lifetime daily exposure is unlikely to result in adverse health effects, based on available hazard assessment data. A modeled long-term concentration greater than a cancer or chronic benchmark is therefore an indicator of some potential for adverse health effects.

In addition, estimated ambient concentrations are also compared to benchmarks for health effect concerns from short-term exposure. While the estimated concentrations in this analysis do not represent short-term peak concentrations typically used to assess acute effects, exceedance of short-term benchmarks by long-term average concentrations is an indication of a potential health concern, because short-term peak concentrations will be higher than annual average concentrations. However, the uncertainties in the benchmarks for short-term exposure are relatively large.

Comparison of estimated HAP concentrations to benchmark concentrations implicitly treats outdoor concentrations as equivalent to exposure concentrations. Outdoor concentrations are a reasonable proxy for exposures that occur both outdoors and indoors, given the high rates of penetration into indoor environments for various HAPs. A field sampling study of indoor and outdoor concentrations of volatile organic compounds (VOCs) reported by Lewis (Lewis 1991) and Lewis and Zweidinger (Lewis and Zweidinger 1992) found that penetration of VOCs from outdoor to indoor air is complete, even when air exchange rates are low. Similar results have been found for particulates less than 10 micrograms in aerodynamic diameter--that is, the penetration of such pollutants from outdoor to indoor air is virtually 100 percent (U.S. Environmental Protection Agency 1996a). Therefore, long term indoor concentrations of both gaseous and particulate HAPs can, in the absence of indoor sources, be assumed to be approximately equal to long term outdoor concentrations in the same location. Indoor removal mechanisms may reduce indoor concentrations to some extent for some HAPs.

To evaluate the potential for individual HAPs to pose health risks, hazard ratios were computed by dividing each estimated HAP concentration by its corresponding benchmark concentration for both cancer and noncancer health effects. Hazard ratios greater than one indicate the estimated concentration was in excess of the benchmark concentration. Hazard ratios were computed for each available benchmark for each census tract.

To evaluate the impacts of air toxics in urban areas, exceedances of benchmark concentrations are evaluated separately for urban census tracts and rural census tracts. Each census tract was designated as either "urban" or "rural" as part of the dispersion modeling methodology, since dispersion parameters differ for these two types of locations. All census tracts with population density greater than 750 people/km^2 are designated as urban, while census tracts with lower population density are designated as rural, based on EPA modeling guidance (U.S. Environmental Protection Agency 1996b). This results in an approximately even split of census tracts into the urban and rural designations, meaning that many suburban areas are classified as "rural" rather than "urban." Characteristics of urban and rural census tracts are shown in Table 4.

3 RESULTS

3.1 HAP Modeling

3.1.1 Pollutant Concentrations

Figure 1 shows boxplots of the modeled concentrations of 38 selected HAPs in the 28,314 urban census tracts. The HAPs shown are those identified in section 3.3 below as having at least 50 urban census tracts with modeled concentrations exceeding health hazard benchmark concentrations. Pollutants are separated into four groups in the figure, according to the magnitude of the modeled concentrations shown on the vertical axes. The vertical lines for each HAP in the figure show the range from the 1st percentile to the 99th percentile of modeled concentrations, while the box shows the range from the 25th to the 75th percentile, and the horizontal line shows the median modeled concentration for urban census tracts. Modeled concentrations of zero were set equal to a minimal value (1×10^{-13}) to accommodate a logarithmic scale. In the fourth panel of the figure, pollutants for which the modeled concentration is zero in a majority of the urban census tracts are shown with a median concentration equal to this minimal value.

For many of the HAPs shown, the distribution of modeled concentrations spans several orders of magnitude; however, the range from the 25th to the 75th percentile is one order of magnitude or less for a majority of the pollutants. Greater variations in the modeled concentrations are seen for pollutants that have a relatively large proportion of emissions from point sources, such as propylene dichloride and hydrazine.

3.1.2 Model Performance

Table 5 summarizes predicted-to-observed concentration ratios for all HAPs for which a significant amount of monitoring data above the minimum detect level was identified. All available observed data from the monitoring programs listed in Table 3 were combined for each HAP. The results for these HAPs show an overall tendency for the model to underestimate the observed concentrations, with geometric mean predicted/observed ratios generally less than 1.0, ranging from 0.09 to 1.0.

P-dichlorobenzene, methylene chloride, and styrene appear to be underpredicted to a greater degree than other gaseous HAPs, with geometric mean predicted-to-observed ratios less than 0.33, suggesting that significant sources have been omitted from the emissions inventory for these pollutants.

Model-monitor comparisons for CO also indicate a tendency for underestimation of concentrations. For the full set of 259 monitors, the geometric mean ratio is 0.52, and for the subset of 100 monitors specifically identified as not related to "hot spots," the geometric mean ratio is 0.62. Further analysis of the predicted-to-observed ratios for CO, described in Chapter 7 and Attachment 5 of the modeling report (Rosenbaum et al. 1998) suggests that much of the model's tendency to underestimate pollutant concentrations may be explained by limitations of the Gaussian model formulation, such as neglect of calm wind conditions, poor representation of stable atmospheric conditions, and the 50 kilometer downwind distance limit. Uncertainties in the HAP emissions inventory may also explain the tendency to underpredict.

Figure 2 presents a comparison of predicted and observed concentrations for 13 gaseous HAPs at 5 locations in the city of Baltimore, Maryland. The overall Spearman correlation coefficient is 0.82 ($p=0.00001$). The high correlation coefficient is an indicator of good performance in distinguishing the relative magnitude of concentrations among the different HAPs included in the data set.

3.2 Benchmark Concentrations

A total of 183 benchmark concentrations were identified for the 148 HAPs in this study, as summarized in Table 6. Seventy-seven of the benchmarks are for cancer, 90 for non-cancer effects from long-term exposure, and 16 for non-cancer effects from short-term exposure. No quantitative benchmarks were identified for 29 of the 148 HAPs, while benchmarks for more than one of the three hazard categories were identified for 60 HAPs.

Out of the 14 pollutant groups included in this study, benchmarks appropriate for applications to the entire group were identified for nine: arsenic compounds, beryllium compounds, cadmium compounds, chromium compounds, cobalt compounds, lead compounds, manganese compounds, nickel compounds, and selenium compounds. For five pollutant groups, no benchmarks applicable to the entire group were identified for antimony compounds, cyanide compounds, glycol ethers, mercury compounds, and polycyclic organic matter. Values of all benchmark concentrations used in this analysis are shown in Attachment 1.

3.3 Benchmark Exceedances

3.3.1 Exceedances of Benchmark Concentrations in Urban and Rural Census Tracts

Table 7 shows the percentage of urban and rural census tracts with modeled 1990 average outdoor concentrations that exceed benchmark concentrations. Results are shown for 38 HAPs with exceedances in more than 50 urban census tracts[2]. An additional 12 HAPs not shown in the table have exceedances in between 10 and 50 urban census tracts, and an additional 17 have exceedances in between 1 and 10 urban census tracts. Three pollutants have exceedances in rural census tracts only; in each case, the number of census tracts is less than five.

A majority of the benchmark concentrations exceeded are for cancer, rather than noncancer effects. This reflects the fact that the cancer benchmarks, set at a one-in-one-million risk level, are generally much lower concentrations than the noncancer benchmarks.

There are eight HAPs (benzene, bis (2-ethylhexyl) phthalate, carbon tetrachloride, chloroform, ethylene dibromide, ethylene dichloride, formaldehyde, and methyl chloride) with benchmark exceedances in all urban and rural census tracts. For each of these HAPs, the background concentration alone, as defined in section 2.1.3 above, exceeds the

[2] Modeled concentrations for many of the HAPs may exceed more than one benchmark, as 60 HAPs have more than one benchmark concentration (separate benchmarks for cancer, non-cancer effects from long-term exposure, and non-cancer effects from short-term exposure). In Tables 7-12, HAP results are shown only for the benchmark with the most exceedances for each HAP.

benchmark concentration for cancer, as shown in Table 8. To evaluate the impact of 1990 anthropogenic emissions, the background concentration was subtracted from the total estimated concentrations, and the remaining concentrations (i.e., modeled 1990 anthropogenic concentrations) were compared to benchmark concentrations, with results also shown in Table 8. Modeled 1990 anthropogenic concentrations for benzene and formaldehyde are estimated to exceed the benchmark concentration in almost all urban census tracts and in more than 87 percent of rural census tracts. Modeled anthropogenic ethylene dichloride concentrations exceed the benchmark concentration in 32 percent of urban census tracts and 11 percent of rural census tracts. The remaining five HAPs have 1990 modeled anthropogenic concentrations that exceed benchmark concentrations in less than 10 percent of both urban and rural census tracts.

For most other HAPs in Table 7, the percentage of urban census tracts with exceedances of benchmark concentrations is two to three times greater than the percentage for rural census tracts for most pollutants. For some pollutants, however, including 1,3-dichloropropene, p-dichlorobenzene and lead, the relative frequency of exceedances in urban areas is much greater. For example, modeled concentrations of 1,3-dichloropropene exceed the cancer Tier II benchmark for this pollutant in 56 percent of urban census tracts and in only 5 percent of rural census tracts. Almost all estimated emissions of this pollutant are associated with consumer lawn care products. National emissions estimates from this category are spatially allocated to census tracts in proportion to residential population, resulting in greater emissions density in urban tracts. For this category, this allocation method may overstate the share of emissions in urban census tracts relative to rural census tracts. P-dichlorobenzene and lead also have large proportions of emissions that are allocated to tracts in proportion to population.

Of the pollutants with more than 50 urban exceedances, only benzotrichloride has a higher frequency of exceedances in rural tracts than in urban tracts. Virtually all of the estimated benzotrichloride emissions used in this analysis were reported to the TRI by four facilities. Two of these facilities, accounting for about 68 percent of the reported emissions, are in rural locations.

3.3.2 Relative Contributions of Area, Point and Mobile Sources

To evaluate the contribution of three broad categories of sources—area sources, point sources, and mobile sources—to exceedances of benchmark concentrations in urban areas, the estimated number of exceedances resulting from each category's emissions was calculated separately. That is, the modeled concentrations associated with area source emissions were compared to the benchmark concentrations for each HAP in each census tract, and the same was done for point source and mobile source emissions.

Area source emissions estimates were developed for 73 of the HAPs included in this analysis. Table 9 lists the HAPs for which area source emissions alone are estimated to result in long-term outdoor concentrations greater than the benchmark concentrations. There are 30 HAPs with modeled exceedances of benchmark concentrations resulting from estimated area source emissions. Six HAPs—acrolein, benzene, 1,3-butadiene, 1,3-dichloropropene, formaldehyde, and chromium—are estimated to have concentrations greater than the benchmarks, from area source emissions alone, in more than 90 percent of urban census tracts. Four of the HAPs shown in the table are estimated to have area source exceedances in less than 0.1 percent of urban census tracts.

Point source emissions have been estimated for all 148 HAPs included in this analysis. There are 63 HAPs with benchmark exceedances in urban census tracts resulting from estimated point source emissions alone; 34 of these have exceedances in more than 50 urban census tracts and are shown in Table 10. In general, point source emissions of individual HAPs tend to result in exceedances in a smaller number of census tracts than area sources: only seven HAPs—arsenic, benzene, 1,3-butadiene, dioxin, chromium, formaldehyde, and nickel—are estimated to exceed the benchmark concentration in ten percent or more of the urban census tracts due to point source emissions alone. Each of these HAPs, except dioxin, also has a large number of exceedances from area source emissions alone.

Mobile source emissions were estimated for 35 HAPs in this analysis. As shown in Table 11, ten HAPs exceed benchmark concentrations in urban census tracts when only mobile source emissions are considered. Five of these HAPs—acrolein, benzene, 1,3-butadiene, chromium, and formaldehyde—have modeled mobile source concentrations that exceed benchmarks in more than 90 percent of urban census tracts, while acetaldehyde is estimated to exceed its cancer benchmark in two-thirds of the urban tracts from mobile source emissions alone. The results shown in Table 11 for particulate HAPs are attributable to estimated emissions from diesel vehicles (for arsenic, chromium, and nickel, based on speciation data in the technical literature (Hildemann et al. 1991; and commercial marine vehicles powered by residual oil (for cadmium and nickel).

The results presented in Tables 9, 10 and 11 consider the impacts of area, point and mobile sources in isolation. For some HAPs, only one of these source category groups appears to account for most of the benchmark exceedances, while for other HAPs the contributions of two or all three of the source category groups are very significant. Table 12 compares the number of estimated exceedances from modeled concentrations for each of the three broad source category groups alone (from Tables 9-11), along with exceedances for all source categories and background concentrations combined (from Table 7). This comparison is shown for each of the 38 HAPs with estimated exceedances in more than 50 urban census tracts. HAPs are listed in order of the number of benchmark exceedances resulting from modeled area source emissions only.

Table 12 shows that modeled concentrations of 1,3-butadiene from area sources alone exceed the cancer benchmark concentration for this HAP in almost every urban census tract, and that the same is also true of modeled mobile source concentrations for this HAP. This suggests that emissions from both area sources and mobile sources would have to be reduced in order to realize urban concentrations of 1,3-butadiene that are lower than this HAP's cancer benchmark concentration. This finding also applies to acrolein, benzene, formaldehyde, and chromium compounds, since each of these HAPs also exceed benchmark concentrations from modeled area sources alone and from modeled mobile sources alone in nearly every urban census tract. Each of these pollutants also has smaller, but still significant, contributions from point sources. A different finding applies to 1,3-dichloropropene. Modeled concentrations of this HAP from area sources alone (consumer lawn care products) also exceed the benchmark concentration in nearly every urban census tract, but there are no estimated emissions of this HAP from mobile sources, and minimal contributions from point sources.

Table 12 also shows that vinyl chloride and p-dichlorobenzene each have modeled concentrations from estimated area source emissions alone that exceed benchmark concentrations in more than 35 percent of urban census tracts. Both pollutants have smaller estimated contributions from other source types. For both of these pollutants, however, the number of benchmark exceedances resulting from area source emissions may be overstated due to uncertainties in the emissions inventory; estimated area source chemical manufacturing emissions of these pollutants have high uncertainties and may be overestimates.

The benchmark exceedances for most of the other pollutants in Table 12 appear to be due to the combined contributions of area sources and point sources, with significant contributions for some HAPs from mobile sources (nickel compounds, arsenic compounds, and particularly acetaldehyde) and from background concentrations. For the last nine HAPs listed in the table, benchmark concentrations are exceeded in fewer than 500 hundred urban census tracts each, and these exceedances are due almost entirely to emissions from point sources.

A correlation analysis of the number of benchmark exceedances for each source category group and the total number of exceedances, for the set of HAPs in Table 12, shows that exceedances from area sources are most strongly correlated with total exceedances. The relationship between the exceedances from area sources and the total, while controlling for mobile sources and point sources, is a correlation of 0.68 (p=0.0001). The correlation between the exceedances from the point sources and the total, while controlling for the area and mobile sources is 0.48 (p=0.0001). The relationship between the exceedances from mobile sources and the total, while controlling for the area and point sources, is a correlation of 0.14 (p=0.0001). This indicates that the exceedances from area sources have the strongest association with total exceedances, and that there is also an important contribution from point sources. Mobile source exceedances do not appear to be associated with total exceedances when considering the full set of HAPs in Table 12. As discussed above, mobile source contributions are very important for several individual HAPs; but for HAPs with large mobile source contributions, there are also large contributions from area sources.

4 LIMITATIONS AND UNCERTAINTIES

The analysis presented in this chapter uses available emissions data, modeling techniques and hazard evaluation data to estimate the frequency with which long-term average concentrations of hazardous air pollutants at the census tract level may be greater than benchmark concentrations. While modeled concentrations are subject to uncertainties arising from both emissions estimates and the modeling methodology, the available monitoring data support the conclusion that exceedances of benchmark concentrations are common. For example, several sources of long-term monitoring data for benzene and 1,3-butadiene show that measured concentrations routinely exceed benchmark concentrations (California Air Resources Board 1995; New York State 1993; Texas Natural Resource Conservation Commission 1997).

4.1 Emissions Estimates

The majority of HAP emissions estimates used in this study were developed through the application of speciation profiles to the 1990 base year national interim emissions inventories for VOCs (1993 version) and particulate matter (PM) (1995 version). The speciation methodology starts with a large data set—national emissions of total VOCs and PM—and breaks it down into relevant component parts, i.e. emissions of each of the HAPs. The strength of this approach is in its comprehensive coverage of sources and in applying a consistent methodology nationally. Uncertainties in this approach are due to uncertainties in the VOC and PM inventories and in the speciation profiles used to estimate the HAP components of the VOC and PM emissions.

Another approach to estimating national HAP emissions for a modeling study is to assemble a variety of different data sources that each address a particular set of HAP emitters (source categories) or a particular geographic area. The strength of this approach is that it frequently has more detailed emissions estimation methodologies. Uncertainties in this approach are due to possible inconsistencies that are introduced by combining data from disparate sources, and the potential for overlooking important emitters.

An important goal for the modeling portion of this study was to approximate actual outdoor concentrations of air toxics in 1990. Therefore, key objectives included comprehensive treatment of emissions and emissions sources, and a consistent approach applicable to the entire continental U.S. The speciation approach to emissions inventory development was chosen for this study because it was the best approach available for developing a comprehensive national modeling emissions inventory within budget and time constraints.

In 1997, EPA released its 1990 National Emission Trends (NET) inventory (U.S. Environmental Protection Agency 1997). This inventory is a revised version of the 1990 interim inventories for VOC and PM used in this study. National emissions totals in the NET inventory are lower than in the interim inventories by 33 percent for VOC emissions and 42 percent for PM. General reductions in VOC and PM emissions would suggest general reductions in the emissions of toxics estimated for this study. However, many of the large reductions in the VOC and PM emissions estimates are concentrated in source categories for which the interim inventory VOC and PM estimates were not used in this study. These categories include: chemical manufacturing and other manufacturing point sources (1990 TRI data were used instead for this study); waste treatment, storage and disposal facilities (alternate EPA data source (Coburn 1995) used instead for this study); and PM area source dust emissions for paved and unpaved roads, wind erosion construction, geogenic wind erosion, and agricultural crops tilling (emissions for these categories were not included in this study because of high uncertainties). In addition, the NET inventory reflects increases of 36-46 percent, compared with the interim inventory used for this study, in PM emissions from point sources and nondust area sources. More detailed analysis of the differences between the interim inventory and the NET inventory, and their relationship to the emissions estimates used in this study, may be found in Chapter 3 of the modeling technical report (Rosenbaum et al. 1998).

Development of HAP emissions estimates from VOC and PM emissions estimates requires the application of speciation profiles. The primary source of many of these profiles is EPA's SPECIATE database (U.S. Environmental Protection Agency 1992). Previous studies have noted problems with specific profiles in the SPECIATE database (Harley et al. 1992; Korc and Chinkin 1993; Ligocki et al. 1992). As a result, profiles from SPECIATE were supplemented or revised using numerous other data sources in the technical literature. These profiles are detailed in Attachment 3 of the modeling technical report (Rosenbaum et al. 1998).

Some of the remaining uncertainties in the emissions inventory used in this study may be particularly important for the development of strategies for reducing risks from area sources. First, there are eight pollutants—1,1,2,2-tetrachloroethane, acrylamide, bis(2-ethylhexyl)phthalate; ethylene dibromide, hydrazine, methylene diphenyl diisocyanate, quinoline, and vinylidene chloride--with no area source emissions estimates in this study, but which do have area source emissions in the emissions inventory for 40 HAPs recently developed as part of the urban area source program. These area source emissions could result in exceedances of benchmark concentrations that have not been estimated in this study. Second, this study's emissions inventory has relatively high contributions for area source chemical manufacturing and pharmaceutical manufacturing for several HAPs, including acrylonitrile, vinyl chloride, ethylene dichloride, chloroform, carbon tetrachloride, and ethyl acrylate. Both the VOC emissions estimates and the speciation profiles for this categories have large uncertainties--possibly resulting in the overestimation of benchmark concentration exceedances resulting from area source emissions for these HAPs.

The comparison of impacts from area sources, point sources, and mobile sources presented in this chapter also has uncertainties attributable to the definition of an "area source." As noted above, the area source definition used in constructing the emissions inventory for this analysis is not equivalent to the statutory definition of area source in CAA section 112. Some emissions treated as area source emissions in this analysis may actually be associated with section 112 major sources rather than section 112 area sources. An evaluation of the emissions inventory compiled for this study found that more than 70 percent of the estimated area source emissions are associated with categories which almost certainly are not CAA section 112 major sources, such as agricultural sources, dry cleaners, consumer and commercial products, and residential fuel combustion. However, significant portions of the area source emissions estimates for some other source categories, such as chemical manufacturing, petroleum refining, oil and gas production, and industrial surface coating, may be attributable to emitters which would be classified as major sources under section 112. Consequently, the relative contributions of area sources to benchmark exceedances in this analysis may be greater than the contributions of emitters defined as area sources under section 112.

4.2 Modeled Concentrations

Comparison of modeled concentrations to the available monitoring data for air toxics indicates that the model estimates have an overall tendency to underestimate measured concentrations (Rosenbaum et al. 1998). A ratio of the modeled concentration to the monitored concentration was calculated for a total of 736 annual averaged monitored concentrations, obtained for 19 HAPs at 81 monitoring locations. The geometric mean of the set of model-monitor ratios is 0.53, and 73 percent of the ratios are less than one. As described in Section 2.1.4 above, only monitoring data sets with measurements below the minimum detection level (MDL, or "non-detect level") totaling less than 10 percent of measurements taken in a year were used in this quantitative model performance evaluation.

It is possible that the findings of an overall tendency to underestimate are biased by the exclusion of measurement data sets dominated by observations below the non-detect level, since the data sets eliminated will tend to be those with lower concentrations. To test this hypothesis, additional model-monitor comparisons were conducted for the 13 HAPs measured in the Urban Air Toxics Monitoring Program with measurements dominated by individual observations below the non-detect level (this analysis is described in Attachment 5 of the modeling report (Rosenbaum et al. 1998)). For these non-detect data sets, the modeled concentration was compared to a range of possible concentrations, which was calculated by assigning two values to each measurement below the non-detect level: a lower bound of zero, and an upper bound of the non-detect level itself.

For these more qualitative model-monitor comparisons, the modeled concentrations were lower than the lower bound of the possible monitored concentration range—an indication of model underestimation—in 57 percent of the 156 cases. The modeled concentrations were greater than the upper bound of the possible monitored concentration range—an indication of model overestimation—in 14 percent of the cases. The modeled concentrations were between the lower bound and the upper bound of the range in 29 percent of the cases, offering no clear information about the comparison between modeled and monitored concentrations. The high frequency of cases in which the modeled concentration is lower than the lower bound of the possible range of modeled concentrations is consistent with the conclusion that the general tendency is for the modeled concentrations to underestimate concentrations found by monitoring.

The tendency to underestimate outdoor concentrations of air toxics could result in underestimation of the frequency with which benchmark concentrations are exceeded. In addition, the modeled concentration outputs do not capture spatial or temporal peak concentrations that could be significant. The modeling approach used for this study estimates annual average concentrations at the census tract level. A census tract average concentration will not reflect areas within a census tract, such as locations close to a stationary source or a major roadway, which may have concentrations substantially greater than the average across the census tract. Also, a long-term average concentration will not reflect short-term elevated concentrations that may also have important health effects. Consequently, a HAP concentration modeled in this study which is less than a benchmark concentration for the HAP does not mean that the benchmark is never exceeded within that census tract; consideration of alternate spatial and temporal scales could potentially identify additional benchmark exceedances.

In addition, the analysis in this chapter only presents the frequency with which benchmark concentrations are exceeded, and does not consider the magnitude of exceedance. A HAP which exceeds its benchmark concentration in a relatively small number of census tracts may exceed that benchmark by a large magnitude, and therefore may pose a greater potential risk than another HAP which exceeds its benchmark in more tracts but with a small magnitude of exceedance.

4.3 Benchmark Concentrations

For this study, a set of benchmark concentrations was compiled from a number of data sources, as described in Caldwell et al (Caldwell et al. 1998). Benchmark concentrations represent an estimated concentration at which a lifetime daily exposure is unlikely to result in adverse health effects, based on available hazard assessment data.

The benchmark concentration for cancer hazard is derived from the unit risk, an upper-bound estimate of the excess cancer risk over background incidence associated with a continuous lifetime exposure. Factors including use of sensitive animal strains, tumor sites of uncertain human relevance, and linear extrapolation to low doses can contribute to uncertainty in estimating the risk in human population (Cogliano 1997). Differences in the pharmacokinetics of pollutants between exposure routes and species are expected, and can have influence on extrapolation of observed responses in animals and humans (U.S. Environmental Protection Agency 1994b).

This analysis emphasizes the inhalation route of exposure as benchmark concentrations were applied to modeled ambient air concentrations. However, health effects information is not always available for the inhalation route of exposure. For cancer benchmarks, extrapolations were needed to use available information from other routes of exposure. When extrapolating between two different routes of exposure (e.g., inhalation vs. oral), a number of factors are important for determining the association between a specific dose and the degree of toxic response engendered by a pollutant. These factors include differences by route of exposure in (1) tissue distribution, (2) rate of delivery leading to differing concentration profiles, (3) degree of metabolism, and (4) response caused by an agent at its site of action across species and among target tissue.

How such uncertainties affected the application of dose-response information for this type of analysis is not clear (U.S. Environmental Protection Agency 1994b). However, in limited comparisons of differences between oral and inhalation dose routes, Pepelko concluded that the carcinogenic potencies are not substantially influenced by dose route (Pepelko 1990). However, the use of information extrapolated from oral to the inhalation route of exposure involves greater uncertainty than using that based on the inhalation route. This uncertainty is addressed by assignment of cancer benchmark concentrations based on extrapolated data to Tier II rather than Tier I.

Benchmarks representing noncancer risks from long-term exposure make use of USEPA Reference Concentrations (RfCs) or similar values representing nonccancer inhalation risks developed by other agencies. The RfC is by definition an estimate with an uncertainty spanning perhaps an order of magnitude. Although severity of effect is considered in the development of RfCs, there is no numerical adjustment for severity. Considerations of uncertainty are numerically represented in the derivation of RfCs to account for differences in human sensitivity, extrapolation from animals to humans, length of study, use of an observed rather than non-observed effect level, and completeness of the database. These uncertainties are address by use of conservative safety factors in derivation of the RfC; however, an RfC is not derived when it is determined that the uncertainties are too great (U.S. Environmental Protection Agency 1990).

In this study, only data on health effects via the inhalation route of exposure were used in establishing noncancer benchmark concentrations. No benchmarks for noncancer effects were developed through extrapolation from data for the oral route of exposure; oral studies are limited as indicators of non-cancer inhalation toxicity because of factors such as portal of entry effects and liver "first-pass effects," as well as lack of consideration of dosimetric considerations (U.S. Environmental Protection Agency 1994b). For HAPs with no EPA inhalation RfCs, California EPA reference exposure levels (RELs) and ATSDR minimal risk levels (MRLs) were used and assigned to Tier II.

Limitations in the availability of toxicity data for HAPs must be considered when assessing potential health impacts of these pollutants. Approximately 20 percent of the modeled HAPs with a weight of evidence indicating potential carcinogenicity do not have a cancer potency estimate and half do not have a benchmark concentration for noncancer health effects (Caldwell et al. 1998). Seventeen of the HAPs considered in this analysis have either an EPA weight-of-evidence determination as known, probable or possible human carcinogens or a recent National Toxicology Program study reporting clear evidence of animal carcinogenicity, but do not have carcinogenic potency estimates. For example, styrene is considered to be a possible (Group C) human carcinogen, but because it has no potency estimate, it was not possible to determine the frequency with which modeled styrene concentrations exceed a benchmark concentration. If styrene were assigned a default potency estimate that is consistent with other Group C carcinogens, modeled concentrations in a number of census tracts would exceed the benchmark concentration.

Even for some of the ubiquitous pollutants identified in this analysis, there is incomplete toxicity information. For example, benzene and 1,3-butadiene have both been associated with reproductive and developmental effects (U.S. Environmental Protection Agency 1994b), but currently have no benchmark concentration for such effects. In addition, 29 of the 148 HAPs included in this study have no Tier I or Tier II benchmark concentrations for any effects even though there are previous studies indicating some of these HAPs are of potential health concern (U.S. Environmental Protection Agency 1994b). For example, n,n-dimethylaniline is ranked by EPA as being of high concern for noncancer effects, but quantitative hazard information is not available.

Another limitation in the toxicity information for the HAPs is in hazard evaluation for chemical groups. Outdoor concentrations were modeled for 14 HAP chemical groups. It is difficult to assess the toxicity of chemical groups, because they are comprised of a number of different species. For example, the HAP listed as "mercury compounds" is made up of several different constituents, including mercuric chloride, elemental mercury, mercuric nitrate, and mercury (aceto) phenyl, all with potentially different levels and types of toxicity. Also, the toxicity of the individual members of the polycyclic organic matter (POM) category varies significantly. This category is very broad and the toxicity of many of its members has not been characterized. However, many studies have shown the potential carcinogenic potency of polycyclic aromatic hydrocarbons—a subset of the POM category—to be large (U.S. Environmental Protection Agency 1993a). Assignment of an appropriate benchmark to this category depends on the extent to which particular POM constituents contribute to overall POM concentrations; differing assignments of hazard potential estimates for POM may profoundly affect estimates of the health risk posed by HAPs.

A further limitation of this analysis is that it only considers the potential health impact of individual pollutants. Additive or synergistic interactions among HAPs may pose a threat to public health beyond that identified in this chapter. HAP concentrations that are less than benchmark concentrations may pose a risk to health when they are considered in combination with concentrations of other HAPs. Currently, too little is known about how pollutants interact to fully evaluate the potential health risks posed by exposure to multiple HAPs at concentrations below toxicity benchmarks.

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Table 1. Surrogates used for proportional allocation of area and mobile source emissions from county level to census tract level

Surrogate for emissions at census tract level	Emissions source categories
Population	Residential heating; architectural coatings; consumer products; non-industrial pesticide application; gasoline service stations; structure fires
1/Population density	Recreational vehicles; construction and construction equipment; aircraft; landfills; wastewater treatment
Roadway miles	Asphalt application
Combination of: Population and roadway miles	On-road mobile source emissions
Railway miles	Railroads
Residential land	Lawn and garden equipment
Commercial land	Commercial and institutional fuel combustion; commercial equipment; dry cleaners; commercial and institutional incinerators and landfills
Industrial land	Industrial fuel combustion; industrial equipment; chemical manufacturing; metal production and products; wood, rubber and plastics products; industrial coatings; degreasing and solvent utilization; chemical and fuel bulk stations/terminals and pipelines; incineration
Residential and commercial land	Non-industrial asphalt roofing
Commercial and industrial land	Petroleum and petroleum products storage and transport
Combination of: population and commercial land	Non-industrial solvent uses
Utility land	Electric utility fuel combustion
Farmland	Farm equipment; agricultural field burning
Orchard land	Orchard heaters
Agricultural land	Agriculture production
Rangeland	Oil and gas production
Forest land	Logging equipment; forest wildfires
Rangeland and forest land	Prescribed burning
Mining and quarry land	Mining and quarrying
Water	Marine vessels

Table 2. Estimated background concentrations of 28 hazardous air pollutants.

Pollutant	**Background Concentration ($\mu g/m^3$)**
Benzene	0.48
Bis(2-ethylhexyl) phthalate	1.60
Bromoform	0.021
Carbon disulfide	0.047
Carbon tetrachloride	0.88
Carbonyl sulfide	1.2
Chlordane	9.9E-06
Chloroform	0.083
Dibutylphthalate	0.0010
Dioxins/furans (toxicity equivalents)	1.5E-08
Ethylene dibromide	0.0077
Ethylene dichloride	0.061
Formaldehyde	0.25
Hexachlorobenzene	9.3E-05
Hexachlorobutadiene	0.0018
Hexachloroethane	0.0048
Lindane	0.00025
Mercury compounds	0.0015
Methyl bromide	0.039
Methyl chloride	1.2
Methyl chloroform	1.1
Methyl iodide	0.012
Methylene chloride	0.15
Phosgene	0.061
Polychlorinated biphenyls	0.00038
Tetrachloroethylene	0.14
Trichloroethylene	0.081
Xylene	0.17

Table 3. Characteristics of hazardous air pollutant monitoring programs used for ASPEN model evaluation. (Time period of data used for comparison.)

Monitoring Program	Number of Monitoring Sites	Number of Hazardous Air Pollutants[1]
California Air Resources Board Ambient Toxics Network (1990)	20	14
San Francisco Bay Area Air Quality Management District (1990)	15	8
South Coast Air Quality Management District (CA) (1990)	4	11
Houston Regional Monitoring Corporation and South East Texas Regional Planning Commission (1990)	12	6
New York State Ambient Toxic Air Monitoring Network (1990)	10	10
Staten Island/New Jersey Urban Air Toxic Assessment Project (1988 – 1989)	3	7
Maryland Department of Environment, Baltimore City (1991 and 1992)	5	13
Urban Air Toxics Monitoring Program (UATMP) (1990 and 1991)	12	10

[1] Excludes HAPs in these programs for which measurements were dominated by values below the minimum detection level, and which therefore were not used for comparisons. Other pollutants not included in this study are also sampled in some of these programs.

Table 4. Population and area statistics for census tracts in the continental U.S.

	Population			Land Area (sq km)		
Percentile	Urban Census Tracts[1]	Rural Census Tracts	All Census Tracts	Urban Census Tracts	Rural Census Tracts	All Census Tracts
1	526	0	0	0.1	0.003	0.01
5	1354	143	739	0.2	1.3	0.2
10	1849	1073	1492	0.3	4.6	0.6
25	2747	2381	2560	0.9	12	1.7
50	3897	3637	3762	1.8	49	6
75	5378	5090	5230	3.1	212	60
90	7105	6763	6931	5	513	295
95	8338	7979	8143	6	942	543
99	11653	11407	11523	10	3084	2155
Mean	4283	3888	4072	2.3	243	131
Total	121 MM	126 MM	247 MM	0.07 MM	7.85MM	7.92 MM
Number of Census Tracts	28,314	32,354	60,668	28,314	32,354	60,668

MM = million

[1]Urban census tracts are defined as those with population density of 750 or more people per square kilometer. Table excludes 135 census tracts with no population and no area.

Table 5. Summary statistics of ratios of ASPEN 1990 concentration predictions to monitored annual average concentrations, for HAPs with available monitoring data.

Pollutant	Number of sites	Geometric mean of ratios	Geometric standard deviation of ratios
Acetaldehyde	32	0.37	2.04
Benzene	81	0.69	1.92
1,3-butadiene	20	0.27	1.72
Carbon tetrachloride	63	1.03	1.42
Chloroform	44	0.62	1.78
Ethylbenzene	24	0.50	2.04
Formaldehyde	34	0.74	2.28
Hexane	2	1.30	1.51
Methanol	4	0.14	2.03
Methyl chloride	5	1.03	1.15
Methyl chloroform	70	0.77	2.18
Methylene chloride	29	0.20	2.12
p-dichlorobenzene	25	0.22	2.50
Styrene	25	0.10	3.00
Tetrachloroethylene	67	0.42	2.81
Toluene	81	0.47	2.06
Trichloroethylene	60	0.96	3.82
2,2,4-trimethylpentane	9	0.80	1.82
Xylene	61	0.48	2.02
OVERALL	736	0.53	2.63

Table 6. Classification of HAP health effects information for comparison with estimated outdoor concentrations[1].

Health Effect	Tier[2]	Number of HAPs with value	Health Effect Value
Cancer[3]	I	40	EPA inhalation unit risk for carcinogenicity
	II	37	EPA oral unit risk for carcinogenicity, expressed in inhalation units; California EPA inhalation unit risk estimate
Noncancer—Chronic[4]	I	33	EPA inhalation reference concentration
	II	57	EPA provisional reference concentration; California EPA reference exposure level; Agency for Toxic Substances and Disease Registry minimum risk level
Noncancer—Acute[5]	I	1	EPA inhalation reference concentration (developmental)
	II	15	EPA LOC/1000

[1] See Attachment 1 for benchmark concentrations for each HAP. Development of benchmark concentrations is described by Caldwell et al. (1998).

[2]The tiers indicate the level of priority for use of toxicological data. Tier I represents those values with the most consistency in derivation and highest level of peer review

[3] The pollutant groups arsenic, beryllium, cadmium, chromium, lead, and nickel compounds have each been assigned a single cancer benchmark concentration applicable to the entire group. Other HAPs with cancer benchmarks are individual pollutants.

[4]The pollutant groups manganese, cadmium, cobalt and selenium compounds have each been assigned a single chronic benchmark concentration applicable to the entire group. Other HAPs with chronic benchmarks are individual pollutants.

[5] The pollutant group chromium compounds has been assigned a single acute benchmark concentration applicable to the entire group. Other HAPs with acute benchmarks are individual pollutants.

Table 7. Exceedances of benchmark concentrations in urban and rural census tracts, for HAPs with exceedances in more than 50 urban census tracts.

Pollutant	Percentage of Urban Census Tracts Exceeding Benchmark[1]	Percentage of Rural Census Tracts Exceeding Benchmark[1]	Type of Benchmark				
			Cancer		Chronic		Acute
			Tier I	Tier II	Tier I	Tier II	
Benzene	100	100	X				
Bis(2-ethylhexyl)phthalate	100	100		X			
Carbon tetrachloride	100	100	X				
Chloroform	100	100	X				
Ethylene dibromide	100	100	X				
Ethylene dichloride	100	100	X				
Formaldehyde[2]	100	100	X				
Methyl chloride	100	100	X				
Butadiene (1,3)	>99	95	X				
Acrolein[3]	>99	84			X		
Chromium compounds[4]	>99	80	X				
Dichloropropene (1,3)	96	27	X				
Acetaldehyde	86	28	X				
Arsenic compounds	77	23	X				
Nickel compounds	57	19	X				
Vinyl chloride	53	16	X				
p-dichlorobenzene	37	5		X			
Acrylonitrile	30	10	X				
Trichloroethylene	28	6	X				
Cadmium compounds	23	7	X				
Dioxins/Furans	22	4	X				
Lead compounds	20	3		X			
Tetrachloroethylene	6	1	X				
Ethylene oxide	3	0.8		X			
Methylene chloride	2	1	X				
Ethyl acrylate	2	0.8		X			
Hydrazine	1	0.5	X				
Quinoline	1	0.5		X			
Hexachlorobenzene	1	0.4	X				
Methylene diphenyl diisocyanate	0.8	0.2			X		
Manganese compounds	0.7	0.4			X		
Propylene dichloride	0.7	0.2		X			
Acrylamide	0.5	0.2	X				
Heptachlor	0.4	0.3	X				
Trichloroethane (1,1,2)	0.4	0.1	X				
Benzotrichloride	0.3	0.4		X			
PCBs	0.2	0.1	X				
Hexachlorocyclopentadiene	0.2	<0.1					X

[1] There are 28,314 urban census tracts and 32,489 rural census tracts.

[2]Formaldehyde also exceeds a chronic toxicity Tier II benchmark in 11% of urban census tracts and 2% of rural census tracts.

[3]Acrolein also exceeds an acute toxicity Tier II benchmark in 1% of urban census tracts and 1% of rural census tracts.

[4]Chromium also exceeds a chronic toxicity Tier II benchmark in 28% of urban census tracts and 6% of rural census tracts, and exceeds an acute toxicity Tier II benchmark in 0.1% of urban census tracts and 0.1% of rural census tracts.

Table 8. Exceedances of benchmark concentrations in urban and rural census tracts for eight HAPs with high background concentrations.

Pollutant	Background Concentration (ug/m^3)	Cancer Benchmark Concentration (ug/m^3)	Percentage of Census Tracts with Exceedances, Disregarding Background[1]	
			Urban	Rural
Benzene	0.48	0.12	>99	87
Bis(2-ethylhexyl) phthalate	1.6	0.25	<0.1	<0.1
Carbon tetrachloride	0.88	0.067	3	2
Chloroform	0.083	0.043	8	8
Ethylene dibromide	0.0077	0.0045	2	1
Ethylene dichloride	0.061	0.038	32	11
Formaldehyde	0.25	0.077	>99	90
Methyl chloride	1.2	0.56	0.2	0.2

[1] There are 28,314 urban census tracts and 32,489 rural census tracts.

Table 9. Exceedances of benchmark concentrations from area source concentrations in urban census tracts.

Pollutant	Percentage of Urban Census Tracts With Benchmark Exceedance[1]	Type of Benchmark			
		Cancer		Chronic	
		Tier I	Tier II	Tier I	Tier II
Butadiene(1,3)	99	X			
Acrolein	99			X	
Benzene	98	X			
Formaldehyde	98	X			
Dichloropropene (1,3)	96	X			
Chromium compounds	90	X			
Vinyl chloride	50		X		
p-dichlorobenzene	36	X			
Nickel compounds	34		X		
Ethylene dichloride	27	X			
Acrylonitrile	25	X			
Arsenic compounds	23	X			
Acetaldehyde	19	X			
Trichloroethylene	15	X			
Cadmium compounds	9	X			
Lead compounds	4		X		
Tetrachloroethylene	3	X			
Chloroform	2	X			
Carbon tetrachloride	2	X			
Ethyl acrylate	1		X		
Methylene chloride	0.5	X			
Dioxins/Furans	0.2	X			
Manganese compounds	0.2				X
Ethylene oxide	0.1		X		
Chloroprene	0.1				X
Propylene dichloride	0.1		X		
Hydrochloric acid	< 0.1			X	
Methyl tert-butyl ether	< 0.1		X		
Maleic anhydride	< 0.1				
Beryllium compounds	< 0.1	X			

[1]Number of urban census tracts = 28314

Table 10. Exceedances of benchmark concentrations from point source concentrations for selected HAPs in urban census tracts[1].

Pollutant	Percentage of Urban Census Tracts With Benchmark Exceedance[2]	Type of Benchmark				
		Cancer		Chronic		
		Tier I	Tier II	Tier I	Tier II	Acute
Chromium compounds	79	X				
Nickel compounds	26	X				
Benzene	25	X				
Arsenic compounds	23	X				
Formaldehyde	15	X				
Dioxins/Furans	12	X				
Butadiene(1,3)	10	X				
Vinyl chloride	7	X				
Ethylene dichloride	7	X				
Acrolein	6			X		
Acrylonitrile	5	X				
Chloroform	5	X				
Cadmium compounds	4	X				
Lead compounds	4		X			
Acetaldehyde	3	X				
Ethylene oxide	2		X			
Ethylene dibromide	2	X				
Trichloroethylene	2	X				
Hydrazine	1	X				
Quinoline	1		X			
Hexachlorobenzene	1	X				
Methylene diphenyl diisocyanate	0.8		X			
Propylene dichloride	0.6			X		
Methylene chloride	0.6	X				
Carbon tetrachloride	0.5	X				
Acrylamide	0.5	X				
Heptachlor	0.4	X				
Tetrachloroethylene	0.4	X				
Manganese compounds	0.4			X		
Trichloroethane(1,1,2)	0.4	X				
p-dichlorobenzene	0.3	X				
Benzotrichloride	0.3		X			
Hexachlorocyclopentadiene	0.2					X
Methyl chloride	0.1	X				

[1]This table shows the percentage of urban census tracts with benchmark concentration exceedances resulting from estimated point source concentrations, for 34 HAPs with point source exceedances in more than 50 urban census tracts. An additional 29 HAPs, not shown in this table, have exceedances from point source concentrations in fewer than 50

urban census tracts. Eighteen out of these 29 have exceedances in fewer than 10 urban census tracts.

[2]Number of urban census tracts = 28314

Table 11. Exceedances of benchmark concentrations from mobile source concentrations in urban census tracts

Pollutant	Percentage of Urban Census Tracts With Benchmark Exceedance[1]	Type of Benchmark			
		Cancer		Chronic	
		Tier I	Tier II	Tier I	Tier II
Butadiene(1,3)	> 99	X			
Formaldehyde	> 99	X			
Benzene	> 99	X			
Acrolein	> 99			X	
Chromium compounds	95	X			
Acetaldehyde	66	X			
Arsenic compounds	23	X			
Nickel compounds	5	X			
Lead compounds	< 0.1		X		
Cadmium compounds	< 0.1	X			

[1]Number of urban census tracts = 28314

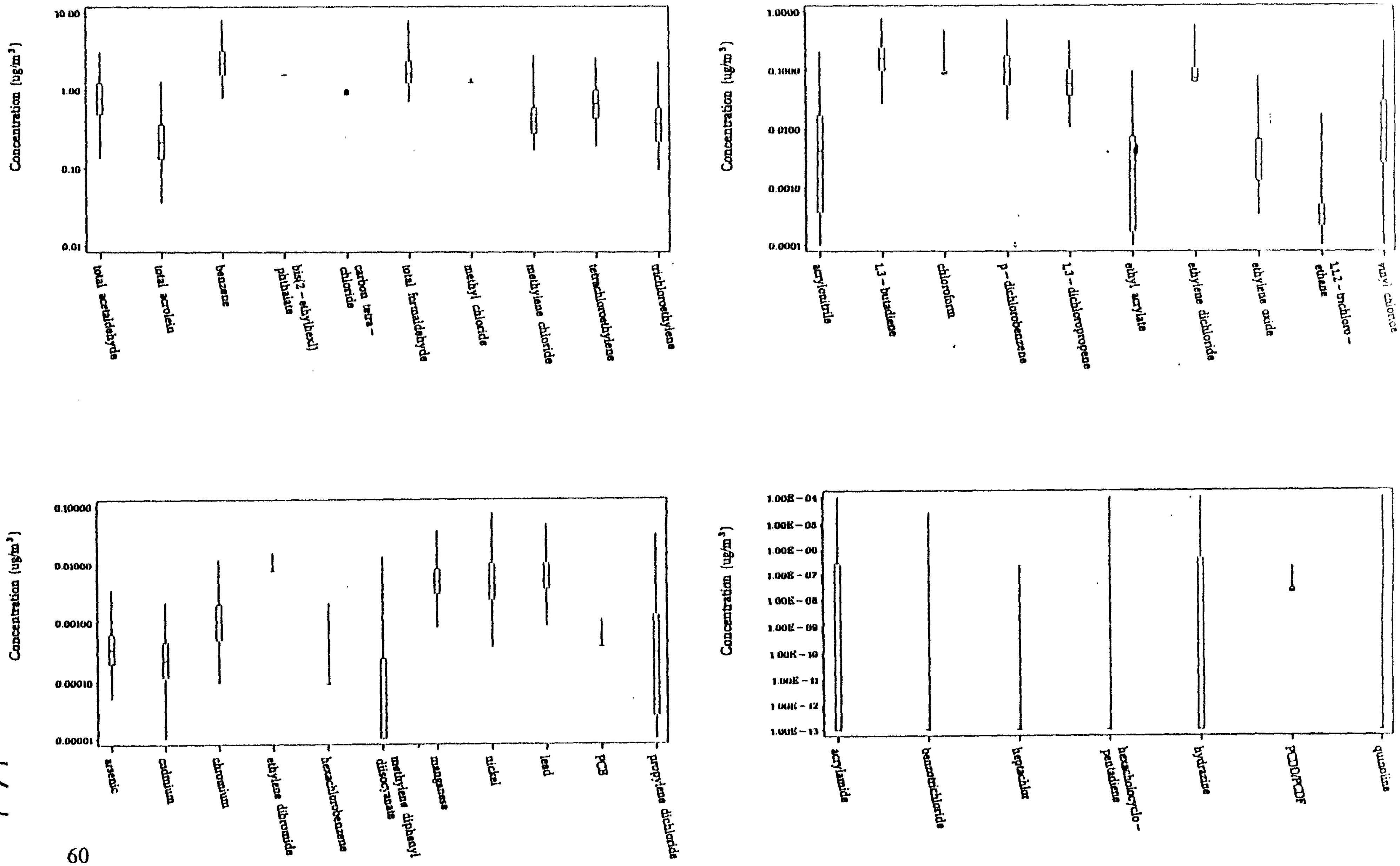
Table 12. Exceedances of benchmark concentrations in urban census tracts, by source category group, for HAPs with estimated exceedances in more than 50 urban census tracts.

	Percentage of Urban Census Tracts Exceeding Benchmark Concentrations			
POLLUTANT	Area Sources	Point Sources	Mobile Sources	Total[1]
Butadiene(1,3)	99	10	>99	>99
Acrolein	99	6	>99	>99
Benzene[2]	98	25	>99	100
Formaldehyde[2]	98	15	>99	100
Dichloropropene (1,3)	96	<0.1	0	96
Chromium compounds	90	79	95	>99
Vinyl chloride	50	7	0	53
p-dichlorobenzene	36	0.3	0	37
Nickel compounds	34	26	5	57
Ethylene dichloride[2]	27	7	0	100
Acrylonitrile	25	5	0	30
Arsenic compounds	23	23	23	77
Acetaldehyde	19	3	66	86
Trichloroethylene[3]	15	2	0	28
Cadmium compounds	9	4	<0.1	23
Lead compounds	4	4	<0.1	20
Tetrachloroethylene	3	0.4	0	6
Chloroform[2]	2	5	0	100
Carbon tetrachloride[2]	2	0.5	0	100
Ethyl acrylate	1	0.1	0	2
Methylene chloride[3]	0.5	0.6	0	2
Dioxins/Furans[3]	0.2	12	0	22
Manganese compounds	0.2	0.4	0	0.7
Ethylene oxide	0.1	2	0	3
Propylene dichloride	0.1	0.6	0	0.7
Ethylene dibromide[2]	0	2	0	100
Methyl chloride[2]	0	0.2	0	100
Bis(2-ethylhexyl)phthalate[2]	0	<0.1	0	100
PCBs[2]	0	0.1	0	0.2
Hydrazine	0	1	0	1
Quinoline	0	1	0	1
Hexachlorobenzene[3]	0	1	0	1
MDI	0	0.8	0	0.8
Acrylamide	0	0.5	0	0.5
Heptachlor	0	0.4	0	0.4
Trichloroethane (1,1,2)	0	0.4	0	0.4
Benzotrichloride	0	0.3	0	0.3
Hexachlorocyclopentadiene	0	0.2	0	0.2

[1] Percentage of urban census tracts with modeled concentrations exceeding benchmarks, considering combined contributions from all source categories and from background.

[2]Pollutants with estimated background concentrations greater than benchmark concentrations.
[3]Pollutants with estimated background concentrations greater than zero but less than benchmark concentrations.

Figure 1. Distribution of modeled concentrations in urban census tracts for 38 selected HAPs.



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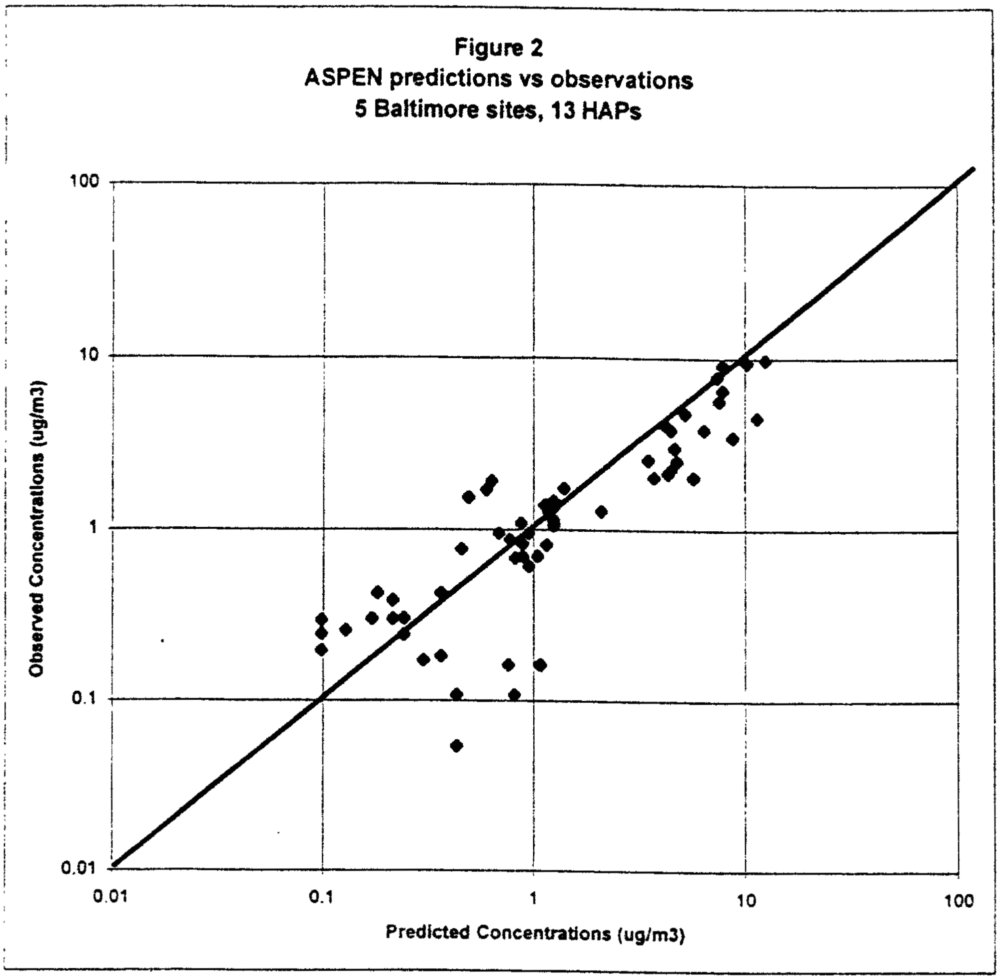
Figure 2
ASPEN predictions vs observations
5 Baltimore sites, 13 HAPs
100
10
1
0.1
0.01
Observed Concentrations (ug/m3)
0.01
0.1
1
10
100
Predicted Concentrations (ug/m3)

Attachment 1
Benchmark Concentrations (ug/m^3) for Hazardous Air Pollutants

HAP	Chronic Toxicity Tier 1	Chronic Toxicity Tier 2	Acute Toxicity	Cancer Tier 1	Cancer Tier 2
Acetaldehyde	9	.	.	0.45	.
Acetamide	.	.	.	.	0.05
Acetonitrile	.	50	.	.	.
Acetophenone	.	.	.	.	.
Acrolein	0.02	.	1.2	.	.
Acrylamide	.	0.7	.	0.00077	.
Acrylic acid	1	.	.	.	.
Acrylonitrile	2	.	.	0.015	.
Allyl chloride	1	.	.	.	0.17
Aniline	1	.	.	.	0.63
Anisidine	.	.	.	.	0.025
Antimony compounds	.	.	.	.	.
Arsenic compounds	.	0.5	.	0.00023	.
Benzene	.	71	.	0.12	.
Benzotrichloride	.	.	0.7	.	0.00028
Benzyl chloride	.	12	5.2	.	0.02
Beryllium compounds	.	0.0048	.	0.00042	.
Biphenyl	.	.	.	.	.
Bis(2-ethylhexyl)phthalate	.	71	.	.	0.25
Bis(chloromethyl)ether	.	.	.	0.000016	.
Bromoform	.	.	.	0.91	.
Butadiene(1,3)	.	8.0	.	.0036	.
Cadmium compounds	.	3.5	.	0.00056	.
Calcium cyanamide	.	.	.	.	.
Captan	.	.	.	.	1
Carbaryl	.	.	.	.	.
Carbon disulfide	700	.	.	.	.
Carbon tetrachloride	.	2.4	.	0.067	.
Carbonyl sulfide	.	.	.	.	.
Catechol	.	.	.	.	.
Chloramben	.	.	.	.	.
Chlordane	.	0.018	.	0.0027	.
Chloroacetic acid	.	.	1.8	.	.
Chlorobenzene	.	70	.	.	.
Chloroform	.	35	.	0.043	.

HAP	Chronic Toxicity Tier 1	Chronic Toxicity Tier 2	Acute Toxicity	Cancer Tier 1	Cancer Tier 2
Chloromethyl methyl ether	.	.	1.8	.	0.0014
Chloroprene	.	1	.	.	.
Chromium compounds	.	0.002	0.05	0.000083	.
Cobalt compounds	.	0.0050	.	.	.
Cresol	.	180	.	.	.
Cumene	.	.	.	.	.
Cyanide compounds	.	.	.	.	.
D(2,4)	.	.	.	.	.
Dibutylphthalate	.	.	.	.	.
Dichlorobenzidene(3,3')	.	.	.	.	0.0078
Dichloroethyl ether	.	.	.	0.003	.
Dichloropropene(1,3)	20		.	0.027	.
Dichlorvos	0.50	.	.	.	0.012
Diethanolamine	.	.	.	.	.
Diethyle sulfate	.	.	.	.	.
Dimethoxybenzidine(3,3')	.	.	.	.	0.0067
Dimethyl formamide	30	.	.	.	.
Dimethyl hydrazine(1,1)	.	0.022	.	.	0.0004
Dimethyl phthalate	.	.	.	.	.
Dimethyl sulfate	.	.	5	.	.
dinitro-o-cresol(4,6)	.	.	0.5	.	.
Dinitrophenol(2,4)	.	.	.	.	.
Dinitrotoluene(2,4)	.	7.0	.	.	0.0091
dioxane(1,4)	.	400	.	.	0.32
Epichlorohydrin	1	.	.	0.83	.
Epoxybutane(1,2)	20	.	.	.	.
Ethyl acrylate	.	48	.	.	0.073
Ethyl carbamate	.	.	.	.	0.036
Ethyl chloride	10,000	.	.	.	.
Ethylbenzene	1000	.	.	.	.
Ethylene dibromide	.	0.20	.	0.0045	.
Ethylene dichloride	.	95	.	0.038	.
Ethylene glycol	.	.	.	.	.
Ethylene oxide	.	600	540	.	0.043
Ethylene thiourea	.	3.0	.	.	0.032
Ethylidenedichloride	.	.	.	.	0.63
Formaldehyde	.	3.6	.	0.077	.
Glycol ethers	.	.	.	.	.

HAP	Chronic Toxicity Tier 1	Chronic Toxicity Tier 2	Acute Toxicity	Cancer Tier 1	Cancer Tier 2
Heptachlor	.	.	.	0.00077	.
Hexachlorobenzene	.	2.8	.	0.0022	.
Hexachlorobutadiene	.	90	.	0.045	.
Hexachlorocyclopentadiene	.	0.07	0.02	.	.
Hexachloroethane	.	80	.	0.25	.
Hexane	200	.	.	.	.
Hydrazine	.	0.24	.	0.0002	.
Hydrochloric acid	20	.	.	.	.
Hydrofluoric acid	.	5.9	1.6	.	.
Hydroquinone	.	.	.	.	.
Lead compounds	.	1.5	.	.	0.013
Lindane	.	1.0	.	0.0026	.
Maleic anhydride	.	2.4	.	.	.
Manganese compounds	0.05	.	.	.	.
Methyl ethyl ketone	1000	.	.	.	.
Mercury compounds	.	.	.	.	.
Methanol	.	620	.	.	.
Methoxychlor	.	.	.	.	.
Methyl bromide	5	.	.	.	.
Methyl chloride	.	.	.	0.56	.
Methyl chloroform	.	320	.	.	.
Methyl hydrazine	.	.	0.94	.	0.0032
Methyl iodide	10	.	.	.	.
Methyl isobutyl ketone	.	.	.	.	.
Methyl isocyanate	.	0.36	4.7	.	.
Methyl methacrylate	.	980	.	.	.
Methyl tert-butyl ether	3000	.	.	.	6
Methylene bis(2-chloroaniline)	.	.	.	.	0.011
Methylene chloride	.	3000	.	2.1	.
Methylene diphenyl diisocyanate	0.02	.	.	.	.
Methylenedianiline(4,4')	.	1.9	.	.	0.0022
N,N-diethyl/dimethylaniline	.	.	.	.	.
Naphthalene	.	14	.	.	.
Nickel compounds	.	0.24	.	0.0042	
Nitrobenzene	.	1.7	.	.	.
nitrophenol(4)	.	.	.	.	.
nitropropane(2)	20	.	.	.	.
o-toluidine	.	.	.	.	0.18

HAP	Chronic Toxicity Tier 1	Chronic Toxicity Tier 2	Acute Toxicity	Cancer Tier 1	Cancer Tier 2
p-dichlorobenzene	800	.	.	.	0.15
p-phenylenediamine	.	.	.	.	.
Parathion	.	.	2	.	.
PCDD/PCDFs	.	3.5E-06	.	3.00E-08	.
Pentachloronitrobenzene	.	.	.	.	0.014
Pentachlorophenol	.	0.2	.	.	0.033
Phenol	.	45	.	.	.
Phosgene	.	0.30	0.8	.	.
Phthalic anhydride	120	.	.	.	.
Polychlorinated biphenyls	.	1.2	.	0.0020	
Polycyclic organic matter	.	.	.	.	.
Propionaldehyde	.	.	.	.	.
Propoxur	.	.	.	.	0.91
Propylene dichloride	4	.	.	.	0.053
Propylene oxide	30	.	.	0.27	.
Propylenimine(1,2)	.	.	.	.	0.00015
Quinoline	.	.	.	.	0.00029
Quinone	.	.	.	.	.
Selenium compounds	.	0.5	.	.	.
Styrene	1000	.	.	.	.
Styrene oxide	.	6.0	.	.	0.022
Tetrachloroethane(1,1,2,2)	.		.	0.017	.
Tetrachloroethylene	.	35	.	1.7	.
Toluene	400	.	.	.	.
Toluene diamine(2,4)	.	.	.	.	0.0011
Toluene diisocyanate(2,4)	0.07	.	7	.	0.091
Trichlorobenzene(1,2,4)	200	.	.	.	.
Trichloroethane(1,1,2)	.	400	.	0.063	.
Trichloroethylene	.	640	.	0.59	.
Trichlorophenol(2,4,6)	.	.	.	0.32	.
Trifluralin	.	.	.	.	0.45
Trimethylpentane(2,2,4)	.	.	.	.	.
Vinyl acetate	200	.	.	.	.
Vinyl bromide	3	.	.	0.031	.
Vinyl chloride	.	26	.	0.012	.
Vinylidene chloride	.	32	.	0.02	.
Xylene	.	300	.	.	.

APPENDIX C:

Recalculation of Specific Results Presented in APPENDIX B:

(*Modeled Outdoor Concentrations of Hazardous Air Pollutants:*

Analysis of Data from the Cumulative Exposure Project

***For the Urban Area Source Program*)**

April, 1999

Ted Palma

Roy Smith

Office of Air Quality Planning and Standards

Introduction

EPA used the CEP urban chapter (Appendix B) as one of three analyses to identify HAPs for listing under section 112(k). All HAPs whose estimated ambient concentrations exceeded risk-based concentrations (RBCs; termed "health benchmarks") in 50 or more of 28,314 urban census tracts were tagged for consideration as section 112(k) HAPs. These results were combined with those from two other analyses of urban HAPs, so this "tag" represented about one-third of the final selection process.

Following the September 1998 urban air toxics strategy proposal, EPA received substantive comments on our use of the CEP in selecting HAPs. First, commentors expressed concern about our inclusion of background in our estimates of ambient concentrations. These commentors believed it was both unfair and counterproductive to consider background levels (caused by natural sources or distant emissions) to select HAPs and source categories for regulation, because background represents emissions that section 112(k) may lack the authority to regulate. This could hypothetically result in punishing industries that emit high-background HAPs with an additional regulatory burden, and lead to regulating emissions that contribute little to overall risk. The CEP analysis estimated that background concentrations for some HAPs were already above RBCs, even in the absence of local emissions, leading directly to an automatic CEP "tag" for consideration as an urban HAP. Although the CEP results represented only one-third of the total urban HAP selection process, this use of background concentrations may have influenced the proposed list.

Second, commentors noted that the background concentration used for one HAP, DEHP, was incorrect. EPA confirmed this, and determined that ambient concentrations should be adjusted for DEHP, independent of the first issue.

Third, commentors pointed out that some RBCs used as benchmarks in the CEP urban chapter (which was developed from work submitted for publication in early 1998) were no longer current, and that some others were not consistent with those used by the OAQPS staff ranking analysis. Although there were few significant discrepancies between the RBCs used by OAQPS and the CEP authors, EPA agreed that some potential existed for the overall 112(k) HAP list to be affected by them.

We addressed all three comments by recalculating the CEP results (percentages of census tracts estimated to exceed RBCs) for specific HAPs, using consistent RBCs and omitting background concentrations.

Methods

Only the 42 HAPs for which EPA has publicly-reviewed inventories were considered for recalculation, because EPA does not intend to propose any other HAPs for listing under section 112(k). Of these 42 HAPs, we selected all that were originally assigned either (1) a background concentration, or (2) an RBC different from the one used in the most recent EPA risk-related ranking analysis (described in Section 2.3 of the Technical Support Document). These criteria produced a list of 23 HAPs (Table C-1) to be recalculated. Of these, 11 HAPs had background concentrations, 8 of which already exceeded the RBC. Twenty-one HAPs had at least one updated RBC, although only 3 carcinogen RBCs and 13 non-carcinogen RBCs had changed more than twofold.

RBCs used in the recalculations were the same as those used for Case 1 of the chronic inhalation indexes used in the risk-related ranking analysis. Ambient concentrations for the 23 HAPs selected for recalculation were modeled for each urban census tract using the most recent version of ASPEN, using the same input assumptions and emission data used for the original CEP modeling. As in Appendix B, urban census tracts were defined as tracts having a population density greater than 750 people/km^2. The number of urban census tracts that were recalculated was 28,272, slightly lower than the 28,314 tracts reported in Appendix B for the original CEP calculations. The modeling conditions were otherwise not altered, and their description in Appendix B remains current. All ratios of modeled concentrations to RBCs were recalculated, and urban census tracts having a ratio greater than one were recounted for each of the 23 HAPs.

Results and Discussion

Table C-2 compares the original CEP urban chapter results with the recalculated results for each of the 23 HAPs, in terms of percentages of census tracts estimated to exceed the RBC. HAPs that exceeded RBCs in 50 or more census tracts (0.177%) were given the CEP "tag" for potential concern.

Three substances (MDI, DEHP, and methyl chloride) that were originally estimated to exceed RBCs in 50 or more census tracts no longer met this criterion. The changed status of MDI resulted from an updated RBC; the other two were influenced primarily by the removal of background concentrations. These three substances have been removed from the list of CEP-recommended urban HAPs. The recalculated results also predicted that beryllium concentrations would exceed its RBC in 445 census tracts. Beryllium has been added to the list of CEP-recommended urban HAPs.

Table C-1. Estimated background concentrations and risk-based concentrations (RBCs) used in original CEP calculations presented in Appendix B, compared with revised RBCs used for recalculation.

Pollutant:	Original Background Conc. (µg/m³)	Cancer Benchmarks		Non-Cancer Benchmarks	
		Original CEP RBC (µg/m³)	Revised RBC (µg/m³)	Original CEP RBC (µg/m³)	Revised RBC (µg/m³)
Arsenic and compounds		0.00023	0.00023	0.5	0.03
Benzene	0.4800	0.12	0.13	71	60
Beryllium and compounds		0.00042	0.00042	0.0048	0.02
Bis(2-ethylhexyl)phthalate (DEHP)	1.6000	0.25	0.42	71	10
Cadmium and compounds		0.00056	0.00056	3.5	0.01
Carbon tetrachloride	0.8800	0.067	0.067	2.4	40
Chloroform	0.0830	0.043	0.043	35	98
Dioxin/furans	1.5E-08	3.0E-08	3.0E-08		
Ethyl acrylate		0.073	0.071	48	-
Ethylene oxide		0.043	0.01	600	5
Ethylene dichloride	0.0610	0.038	0.038	95	810
Ethylene dibromide	0.0077	0.0045	0.0045	0.2	0.2
Formaldehyde	0.2500	0.077	0.077	3.6	3.7
Hydrazine		0.0002	0.0002	0.24	0.2
Lead		0.013	0.083	1.5	1.5
Methyl chloride	1.2000	0.56	0.56	-	100
4,4'-Methylenediphenyl diisocyanate (MDI)				0.02	0.6
Nickel		0.0042	0.0042	0.24	0.20
Tetrachloroethylene (PCE)	0.1400	1.7	0.17	35	270
Trichloroethylene (TCE)	0.0810	0.59	0.50	640	600
Vinyl chloride		0.012	0.012	26	5
Vinylidene chloride		0.02	0.02	32	20
Xylenes				300	430

Table C-2. Comparison of original CEP results (described in Appendix B) with recalculated results based on revised risk-based concentrations (RBCs), with background removed. (Background concentrations were also removed for the original results in this table.) HAPs for which modeled concentrations exceeded their RBC in 50 or more urban census tracts (0.177% of 28,272 total urban census tracts) were deemed to pose a potential health risk.

HAP	Original CEP Results (from Appendix B)	Recalculated CEP Results
Arsenic and compounds	77%	95.5%
Benzene	100%	99.9%
Beryllium and compounds	<0.1%	1.57%
Bis(2-ethylhexyl)phthalate (DEHP)	100%	0.000707%
Cadmium and compounds	23%	76.7%
Carbon tetrachloride	100%	2.64%
Chloroform	100%	7.02%
Dioxin/furans	22%	66.8%
Ethyl acrylate	2%	1.75%
Ethylene oxide	3%	16.0%
Ethylene dichloride	100%	31.8%
Ethylene dibromide	100%	1.83%
Formaldehyde	100%	99.9%
Hydrazine	1%	1.33%
Lead	20%	58.1%
Methyl chloride	100%	0.124%
4,4'-Methylenediphenyl diisocyanate (MDI)	0.8%	0%
Nickel	57%	79.1%
Tetrachloroethylene (PCE)	6%	95.5%
Trichloroethylene (TCE)	28%	28.4%
Vinyl chloride	53%	52.6%
Vinylidene chloride	<0.1%	0.0778%
Xylenes	<0.1%	0%